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NZIC Chemistry IN NEW ZEALAND

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UP FRONT ...

For further details see the cover story on page 2

NZIC Chemistry IN NEW ZEALAND

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IN THIS ISSUE ...

COMING UP ...

July 1995 - Focus on Nutrition, Pharmaceuticals and Cosmetics

September 1995 - Focus on the Dairy Industry

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COVER STORY

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You can carry out measurements with all your sensors within a method, for example you can measure pH as well as temperature. These values can be utilised in any result calculations.

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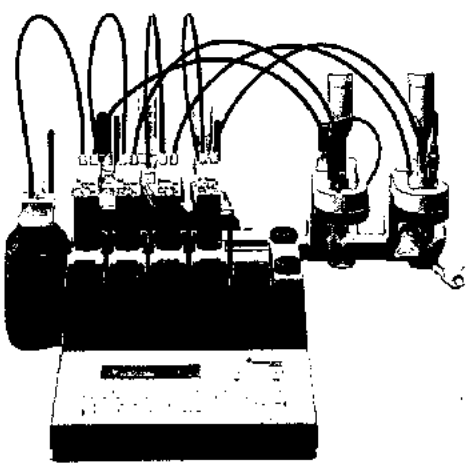

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Some Speculations on Atmospheric Carbon Dioxide Control

A.G.Williamson
Thermocell Limited, P O Box 12205 Christchurch

INTRODUCTION

In recent years the emphasis in energy studies has shifted from sources (how much of various fuels have we left?) to sinks (how much of the products of fossil-fuel use can the environment continue to accept?)

The greenhouse effect has long been known and recognised as essential to the existence of most of the life forms on the planet. Without it the ambient temperature would be below the freezing point of water. There is no doubt that carbon dioxide is a major contributor to the greenhouse effect.

There is no doubt that the global average temperature has risen by more than 0.5°C in the past 100 years. Nor is there any doubt that the carbon dioxide concentration in the atmosphere has risen by about 25% in the same period. What might be argued is the extent to which these two effects are linked. There may even be argument about whether or not global warming is a bad thing. I do not wish in this article to enter into any of these arguments in detail except to point out that there is strong evidence from climate modelling work that increases in atmospheric carbon dioxide and global temperature rise are linked and that quite small changes in global average temperature can have very large effects on climate. My personal view, and it is a view that is held by many scientists in the energy and climate fields, is that given this information it is unwise for us to continue increasing the atmospheric carbon dioxide inventory.

There are three lessons that we might learn from the CFC/ ozone situation, namely:

1) The effects of gaseous emissions to the atmosphere are global.
2) The induction period for the effects is likely to be so long that the problem is highly developed before its existence can be confirmed.
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This is the basis of the Framework Convention on Climate Change (FCCC) which about 150 countries, including New Zealand have signed and ratified in recent years. This agreement commits us to working towards the reduction of anthropogenic carbon dioxide emissions and the increase in carbon dioxide sinks. In signing the FCCC, the New Zealand Government expressed its intention to reduce carbon dioxide emissions to 1990 levels by the year 2000. Since then however the Government has asserted that the restraint applies to net emissions rather than gross emissions. That is to say the Government reckons to offset absorption by forest planting against emissions from fossil fuel burning.

What do these arguments mean in terms of actual carbon dioxide emissions? For many thousands of years until about 1850, the carbon dioxide concentration in the atmosphere was approximately constant at about 290 parts per million. Since then it has been rising at an ever increasing rate and now stands at about 350 parts per million. This is illustrated by the first part of the curve in Figure 1.

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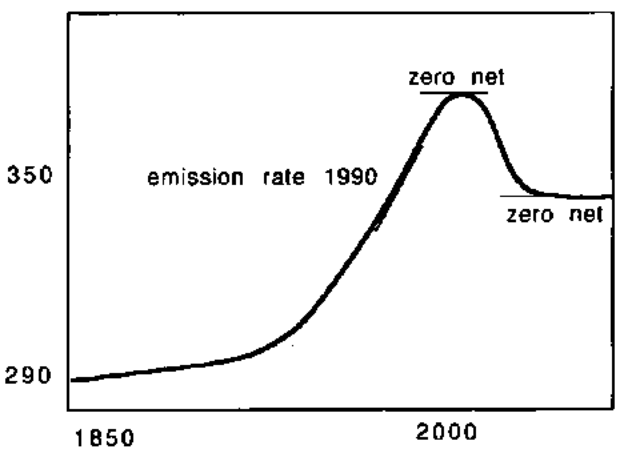

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The New Zealand Branch of the International Solar Energy Society (Solar Action) has recently obtained a legal opinion which supports the contention that our obligation under FCCC applies to gross rather than net emissions. That is, our obligation is to both reduce anthropogenic carbon dioxide emissions AND increase sinks not simply to reduce NET emissions

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maintained by the achievement of ZERO NET EMISSIONS. As shown in figure 1 this may need to preceded by a period of negative net emissions to bring the concentration down to the acceptable level whatever that is. Such a progression will certainly be necessary if, as I suspect will be the case, it is decided that the sustainable level is below the current level at the time the decision is made.

New Zealand's present anthropogenic emission of carbon dioxide is about 28 million tonnes per year (7.6 million tonnes per year of carbon) or about 2 tonnes of carbon per person. This is about twice the world average on a per-capita basis.

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There have been many proposals for reducing carbon dioxide emissions and these fall into six main groups:

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c) biological measures such as afforestation and/or the use of biomass fuel systems in which the carbon is recycled
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e) technical measures such as the removal of carbon dioxide from fossil fuel combustion gases or from the atmosphere by chemical means.
f) technical measures such as the substitution of non-carbon producing energy sources like nuclear and solar energy

The first four of these options have been fairly widely canvassed and every so often someone comes up with the assertion that chemical engineers ought to be able to solve the problem by capturing the carbon dioxide from the atmosphere or from combustion gases and somehow "fixing" it in a non-volatile form. In order to talk about such proposals one needs to answer the following questions:

1) how much energy does one get from burning fossil fuels?
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The answers to the first two questions are contained in Table 1. The answer to the third question will depend on precisely how one goes about the process, however it is possible to make some generalisations based on thermodynamics.

FUEL	tonnes C/TJ	tonnes CO_2/TJ
natural gas	14-15	53-56
oil	18-20	67-74
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The process of separating carbon dioxide from air described by the equation

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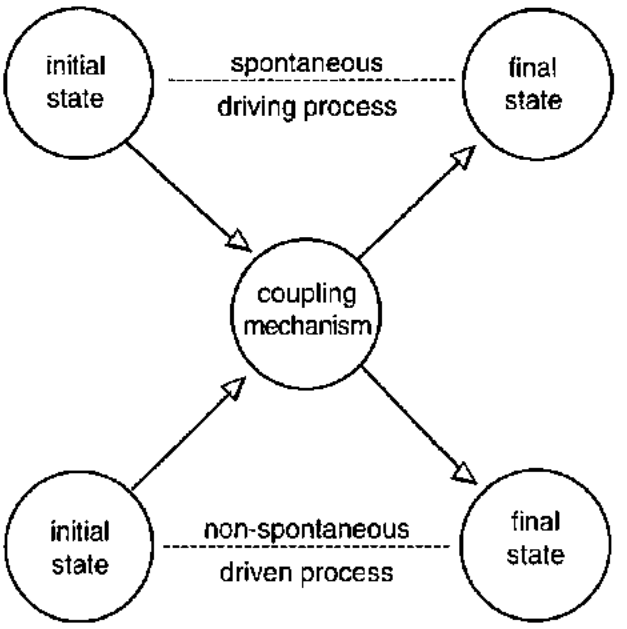
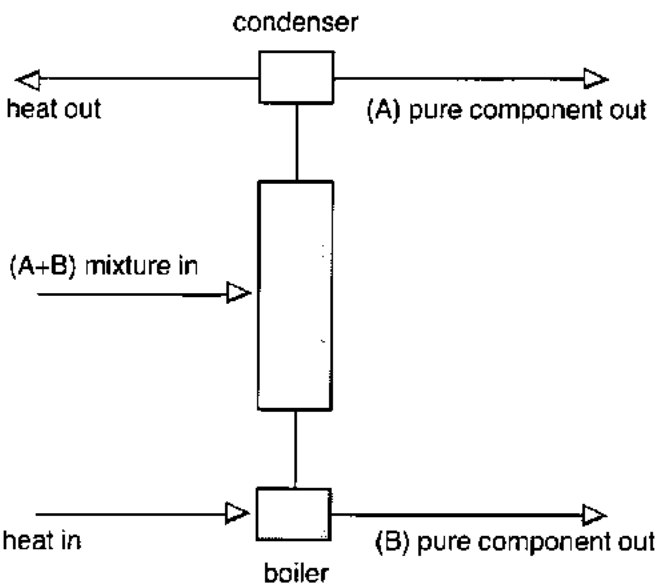
is known to be UNNATURAL, that is it doesn't happen spontaneously. In thermodynamic terms the Gibbs energy is positive and to carry out the process will require some special mechanism and a work input. This work will in turn be derived from some other natural (spontaneous) process. This situation is typical of the basic problem of many chemical engineering processes, namely how to couple a spontaneous process to a non-spontaneous process in such a way that the first can "drive" the second as illustrated in Figure 2.

Figure 2: Coupled Processes



While thermodynamics cannot tell us directly what the detailed coupling mechanism might be, it is able to indicate whether or not the coupling of two processes is likely to be fruitful. A classic example of this is the fractionating column which can be represented as in Figure 3 in which the spontaneous process, transfer of heat from a high temperature (the reboiler) to a low temperature (the condenser) is used to drive the non-spontaneous process (separation of the mixture).

Figure 3: Fractional Distillation



In the example the separation of an equimolar mixture is driven by the transfer of heat from the boiling point of the less volatile component to the boiling point of the more volatile component. The minimum work required for the separation of a mixture of

x_1 moles of component 1 and x_2 moles of component 2 is given by the negative of the Gibbs energy of mixing DG where

$$\Delta G = -RT(x_1 \ln x_1 + x_2 \ln x_2)$$
$$= -2RT(0.5 \ln 0.5)$$
$$= -2121 \text{ J/mol} \quad \text{----------(1)}$$

The maximum work obtainable from the heat flux in the distillation of a mixture of two components with boiling points about 373 K and a boiling point difference of about 10 K is given by

$$w = Q\,(T(high)-T(low))/\,T(high)$$
$$= 873 \text{ J/mol} \quad \text{----------(2)}$$

where equation (1) refers to the separation of a mole of mixture and equation (2) refers to a mole of mixture boiled in the still.

Thus to separate 1 mole of mixture will require the boiling of 2.5 mole of material in the boiler and this in turn requires the input of 2.5 mole of heat of vaporisation or about 81000 J. This suggests that the minimum possible reflux ratio for the separation is 5:1. In very simple first law terms the maximum possible efficiency is 20%. More commonly fractional distillation is around 3-10% efficient in these terms.

Applying the same reasoning to the separation of carbon dioxide from the atmosphere we get for the free energy of separation

$$(CO_2(x=0.0003) + AIR(x=0.9997)) \rightarrow 0.0003CO_2(x=1) + 0.9997AIR(x=1)$$

$$\Delta G = -RT(0.0003 \ln(0.0003) + 0.9997 \ln 0.9997)$$
$$= 23000 \text{ J/mol of } CO_2$$

Given that the reaction

$$CH_4\,(g) + 2O_2(g) \rightarrow CO_2\,(g) + 2H_2O(g) \quad (300\text{ K}, 1\text{bar})$$

has a Gibbs energy of combustion and a heat of combustion of about 800000 J/mol we might expect to use as little as 3% of the energy of combustion to drive the separation. However most separation processes turn out to be around 10 % (or less) efficient so that in practice we could expect to sacrifice something of the order of 35% or more of the total power producing capability of the generating station to separate from the atmosphere an amount of carbon dioxide equal to that produced by the station.

The price is not so high if one processes the flue gas before it is diluted into the atmosphere. Because the gas is more concentrated the Gibbs energy of separation is lowered to about 10000 J/mole CO_2, and the actual energy of separation would be more likely to be about 17-25% of the station output. In any case there is still the problem of disposal of the CO_2. Most speculators suggest liquefaction and storage in disused oil wells. This would essentially require compression of the gas to about 60 bar pressure. For this the simple thermodynamic relation

$$w = nRT\gamma((r)(\gamma-1)/\gamma-1)/(\gamma-1)$$

where γ is the heat capacity ratio, r is the compression ratio and n is the number of compression stages giving (for three stage compression with intercooling) about 12000 J/mol as the lower limit. Practical compression would be more likely to need about 18000-20000 J/mol. So to separate and liquefy the flue gas from a methane burning power station would be expected to take 60000-120000 J/mole or about 20-40% of the power potential of the station. The loss would be a little less (20-30%) for a gas fired combined cycle station. For an oil-fired station with a 27% higher carbon/energy ratio the percentage loss would be correspondingly higher at around 30-50% of the power output and for a coal fired station the loss would be expected to rise to 48-65%.

An alternative process which has been suggested is to dissolve the carbon dioxide in water and to inject the saturated solution into the ocean at an appropriate depth so that the carbon dioxide will remain trapped there.

The solubility of CO_2 in water at 283 K and 1 bar is about 2 g/L. To scrub the CO_2 out of the flue gas one has the choice of a range of pressures and quantities of solvent. As an example I have chosen to use about the amount of water one would have as the coolant flow to a power station of moderate efficiency. This leads to a choice of about 10 bar as the solution pressure. According to my estimates this would require about 70000 J/mol-CO_2 for the compression energy of which one might recover about 25000 J/mol-CO_2 on expansion of the scrubbed gas. To this would be added about 30000 J/mol CO_2 of pumping energy for circulating the scrub water plus whatever extra energy would be needed to get the solution to its final destination at 100m or more depth. Again one finishes up with in excess of 25% of the energy of the power plant being devoted to CO_2 removal and even then it is removed in a way that is only temporary.

Moreover one should remember that a 33% reduction in net usable power output means a 50% increase in total fuel use to achieve a given output. To a first approximation the plant required to remove the CO_2 will be similar in size and cost to that used to produce the power in the first place so that one can expect the capital cost of the CO_2-free power plant to be about twice that of the conventional power plant.

Although the numbers given here are generalisations I would expect most actual separation processes to lie in the ranges given. One should however not forget that the lower limits indicated by the thermodynamics might be approached more closely by some particularly well chosen and well engineered processes. In this sense the prospect of producing CO_2-free fossil-fuelled electricity generation has some, but only slight, hope. On the down side the "storage " of pure CO_2 is likely to be only a temporary palliative. The expected cost of electricity would be something over twice the cost of production without carbon removal. ECNZ in their submissions to the Stratford inquiry referred to a study of some specific carbon dioxide removal processes which suggested a 120% increase in the cost of electricity production if carbon removal from flue gas were to be required.

CHEMICAL FIXATION

Slightly more permanent fixation of carbon can be envisaged in the form of bicarbonate formed by the reaction

$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$$

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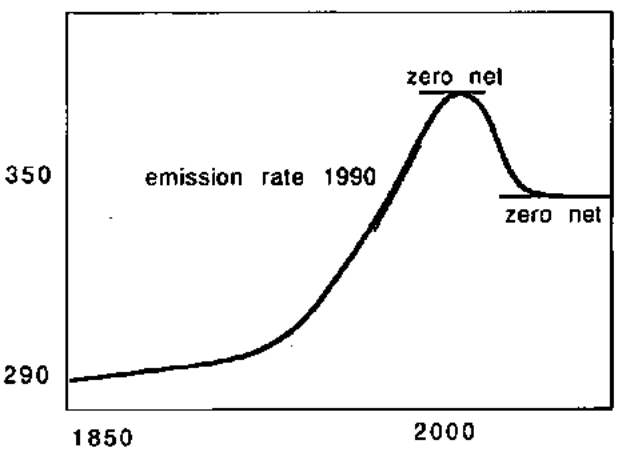

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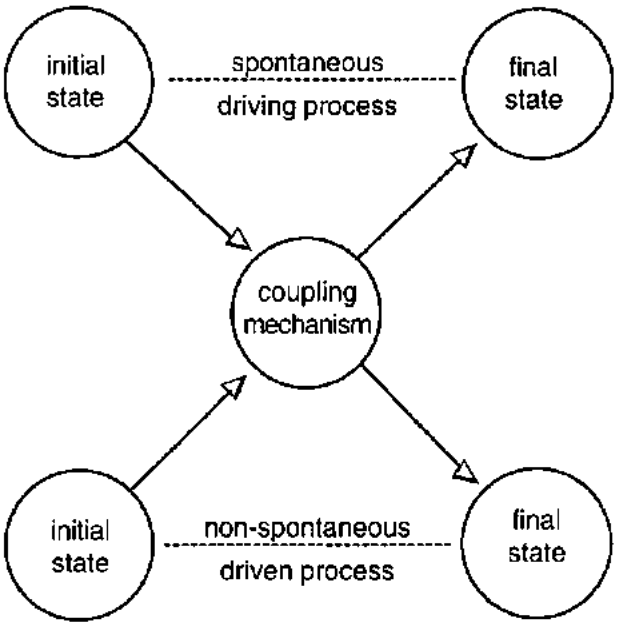
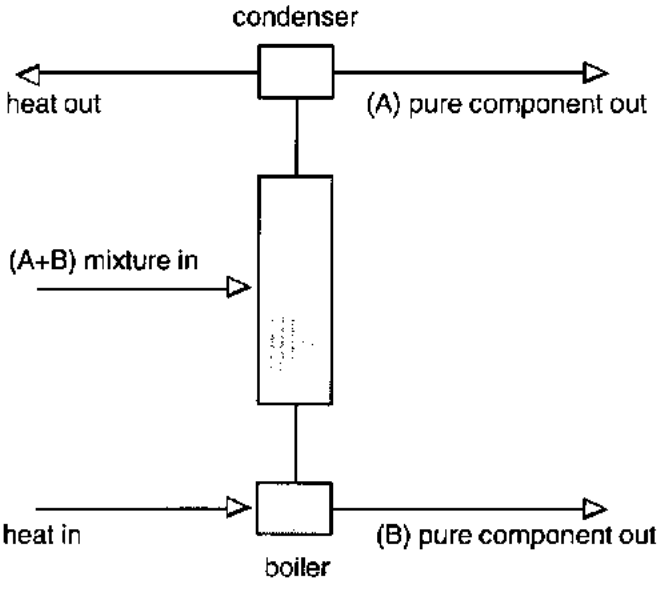
is known to be UNNATURAL, that is it doesn't happen spontaneously. In thermodynamic terms the Gibbs energy is positive and to carry out the process will require some special mechanism and a work input. This work will in turn be derived from some other natural (spontaneous) process. This situation is typical of the basic problem of many chemical engineering processes, namely how to couple a spontaneous process to a non-spontaneous process in such a way that the first can "drive" the second as illustrated in Figure 2.

Figure 2: Coupled Processes



While thermodynamics cannot tell us directly what the detailed coupling mechanism might be, it is able to indicate whether or not the coupling of two processes is likely to be fruitful. A classic example of this is the fractionating column which can be represented as in Figure 3 in which the spontaneous process, transfer of heat from a high temperature (the reboiler) to a low temperature (the condenser) is used to drive the non-spontaneous process (separation of the mixture).

Figure 3: Fractional Distillation



In the example the separation of an equimolar mixture is driven by the transfer of heat from the boiling point of the less volatile component to the boiling point of the more volatile component. The minimum work required for the separation of a mixture of

x_1 moles of component 1 and x_2 moles of component 2 is given by the negative of the Gibbs energy of mixing DG where

$$\Delta G = -RT(x_1 \ln x_1 + x_2 \ln x_2)$$
$$= -2RT(0.5 \ln 0.5)$$
$$= -2121 \text{ J/mol} \quad \text{----------(1)}$$

The maximum work obtainable from the heat flux in the distillation of a mixture of two components with boiling points about 373 K and a boiling point difference of about 10 K is given by

$$w = Q\,(T(high)-T(low))/\,T(high)$$
$$= 873 \text{ J/mol} \quad \text{----------(2)}$$

where equation (1) refers to the separation of a mole of mixture and equation (2) refers to a mole of mixture boiled in the still.

Thus to separate 1 mole of mixture will require the boiling of 2.5 mole of material in the boiler and this in turn requires the input of 2.5 mole of heat of vaporisation or about 81000 J. This suggests that the minimum possible reflux ratio for the separation is 5:1. In very simple first law terms the maximum possible efficiency is 20%. More commonly fractional distillation is around 3-10% efficient in these terms.

Applying the same reasoning to the separation of carbon dioxide from the atmosphere we get for the free energy of separation

$$(CO_2(x=0.0003) + AIR(x=0.9997)) \rightarrow 0.0003CO_2(x=1) + 0.9997AIR(x=1)$$

$$\Delta G = -RT(0.0003 \ln(0.0003)+0.9997 \ln 0.9997)$$
$$= 23000 \text{ J/mol of } CO_2$$

Given that the reaction

$$CH_4\,(g) + 2O_2(g) \rightarrow CO_2\,(g) + 2H_2O(g) \quad (300\text{ K}, 1\text{bar})$$

has a Gibbs energy of combustion and a heat of combustion of about 800000 J/mol we might expect to use as little as 3% of the energy of combustion to drive the separation. However most separation processes turn out to be around 10 % (or less) efficient so that in practice we could expect to sacrifice something of the order of 35% or more of the total power producing capability of the generating station to separate from the atmosphere an amount of carbon dioxide equal to that produced by the station.

The price is not so high if one processes the flue gas before it is diluted into the atmosphere. Because the gas is more concentrated the Gibbs energy of separation is lowered to about 10000 J/mole CO_2, and the actual energy of separation would be more likely to be about 17-25% of the station output. In any case there is still the problem of disposal of the CO_2. Most speculators suggest liquefaction and storage in disused oil wells. This would essentially require compression of the gas to about 60 bar pressure. For this the simple thermodynamic relation

$$w = nRT\gamma((r)(\gamma-1)/\gamma-1)/(\gamma-1)$$

where γ is the heat capacity ratio, r is the compression ratio and n is the number of compression stages giving (for three stage compression with intercooling) about 12000 J/mol as the lower limit. Practical compression would be more likely to need about 18000-20000 J/mol. So to separate and liquefy the flue gas from a methane burning power station would be expected to take 60000-120000 J/mole or about 20-40% of the power potential of the station. The loss would be a little less (20-30%) for a gas fired combined cycle station. For an oil-fired station with a 27% higher carbon/energy ratio the percentage loss would be correspondingly higher at around 30-50% of the power output and for a coal fired station the loss would be expected to rise to 48-65%.

An alternative process which has been suggested is to dissolve the carbon dioxide in water and to inject the saturated solution into the ocean at an appropriate depth so that the carbon dioxide will remain trapped there.

The solubility of CO_2 in water at 283 K and 1 bar is about 2 g/L. To scrub the CO_2 out of the flue gas one has the choice of a range of pressures and quantities of solvent. As an example I have chosen to use about the amount of water one would have as the coolant flow to a power station of moderate efficiency. This leads to a choice of about 10 bar as the solution pressure. According to my estimates this would require about 70000 J/mol-CO_2 for the compression energy of which one might recover about 25000 J/mol-CO_2 on expansion of the scrubbed gas. To this would be added about 30000 J/mol CO_2 of pumping energy for circulating the scrub water plus whatever extra energy would be needed to get the solution to its final destination at 100m or more depth. Again one finishes up with in excess of 25% of the energy of the power plant being devoted to CO_2 removal and even then it is removed in a way that is only temporary.

Moreover one should remember that a 33% reduction in net usable power output means a 50% increase in total fuel use to achieve a given output. To a first approximation the plant required to remove the CO_2 will be similar in size and cost to that used to produce the power in the first place so that one can expect the capital cost of the CO_2-free power plant to be about twice that of the conventional power plant.

Although the numbers given here are generalisations I would expect most actual separation processes to lie in the ranges given. One should however not forget that the lower limits indicated by the thermodynamics might be approached more closely by some particularly well chosen and well engineered processes. In this sense the prospect of producing CO_2-free fossil-fuelled electricity generation has some, but only slight, hope. On the down side the "storage " of pure CO_2 is likely to be only a temporary palliative. The expected cost of electricity would be something over twice the cost of production without carbon removal. ECNZ in their submissions to the Stratford inquiry referred to a study of some specific carbon dioxide removal processes which suggested a 120% increase in the cost of electricity production if carbon removal from flue gas were to be required.

CHEMICAL FIXATION

Slightly more permanent fixation of carbon can be envisaged in the form of bicarbonate formed by the reaction

$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$$

However this would require the mining of about 7 tonnes of limestone for each tonne of oil burned and the disposal of the bicarbonate solution. Similarly the use of naturally occurring iron oxides to produce the marginally stable ferrous carbonate would also involve the mining of many tonnes of iron ore for each tonne of oil burned.

More permanent fixation can also be achieved through biological processes of which tree growth is the most obvious. There are two aspects of afforestation which are significant:

1) rate of fixation and
2) steady state carbon "storage".

The rate of fixation of good forest is about 8 tonnes of carbon per hectare per year or about 30 tonnes of carbon dioxide per hectare per year. Unfortunately the forest will mature to a steady state at which the net carbon dioxide fixation rate is zero. At this point the amount of carbon sequestered is about 250 tonnes per hectare. The timber then has to be harvested and stored and/or more forest has to be planted. To give an idea of the timber storage required, the amount of wood which would sequester 30 years of carbon output from a 1000 MW thermal power station burning coal (e.g. Huntly when gas runs out) is about 150 million cubic metres (a stack 3 km square and 15 metres high). The area of forest required to process the fossil fuel derived carbon with continuous milling is about 250000 hectares. Once established such an area could be used as a fuel source in its own right so long as it was continuously harvested and replanted. Because of the lower calorific value of wood the actual area required for sustainable power production would be rather larger than that required simply to absorb the carbon from coal or oil burning . The area of New Zealand pine forest needed to fix sunlight at a useable rate of 1000 MW would be about 300000-400000 hectares. This is equivalent to around 4-5% of our present total forested land or about 20-25% of our present plantation forest. To cope with the 6000 megawatts of additional generation which a recent ECNZ study claims will be necessary over the next 20 years (most of which will be thermal) we shall need to approximately quadruple our existing plantation forest.

CALCIUM CARBONATE AS A CARBON SINK

By far the largest natural store of carbon is in inorganic carbonates notably limestone. There do exist mechanisms for removing carbon dioxide from the atmosphere as calcium carbonate. The chief source of calcium which is not already locked up as solid carbonate is the ocean which is estimated to contain somewhere around 10^{19} moles of calcium ion - enough to fix 10^{14} tonnes of carbon. Because of the high energy price of doing this by chemical engineering methods it is better to look to the photochemical or biochemical methods used by natural organisms. The main contenders in this field are shellfish and corals. I have not yet found any definitive data on the rate of growth of shellfish. One can however estimate that the deposition required to fix New Zealand's anthropogenic carbon emissions of 7 million tonnes per year would be about 18 million tonnes of shell or about 9 million cubic metres per year. Given that the shore line is of the order of 10 million metres long this corresponds to about 1 cubic metre of shell per metre of shoreline per year. My guess is that this is not feasible unless one sets out to farm shellfish as carbon fixers.

More seems to be known about the growth of corals. Kinsey and Hopley have examined the rates of growth of corals and conclude that currently coral growth produces around 10^9 tonnes of $CaCO_3$ per year consuming about 1.5% of the carbon produced by fossil fuel use and deforestation. Based on estimates of coral growth rates a major coral farming operation aimed at fixing all of the anthropogenic carbon dioxide production would need about 10 million square kilometres - about 2% of the total ocean area or about 20% of the warm ocean areas. Once again one is forced to the conclusion that, while coral growth offers some potential for further carbon fixation it is highly unlikely to be a major contributor. It is interesting to note that from the available data coral growth appears to have about the same capability per unit area for carbon fixing as does forest growth.

Avoiding carbon dioxide production

The alternatives to burning fossil fuels are nuclear power and solar power. We have already experienced some of the disadvantages of nuclear power production including its high costs and relatively high risks. We have yet to face up to the problems of decommissioning nuclear power stations at the end of their lives. Solar power, and under this heading I include all the solar derived energy sources such as wind and wave power, have yet to receive the attention they deserve. Some solar technologies such as wind and photovoltaic generation of electricity are already technically feasible. Wind power is economically viable as a major contributor to a hydro based grid system such as we have in New Zealand. Photovoltaic electricity is economically viable for special applications and is not far from being a general purpose source. Biomass has a growing place and is of particular interest as a base for liquid chemical transport fuels. While biomass production is a low efficiency use of sunlight there are other approaches to producing a photochemical-based fuel. Water splitting cycles and the use of biochemical reactions for the direct fixation of solar energy into chemical form are particular areas where some work has been done and where there is potential for real progress towards the creation of an energy rich but clean world.

CONCLUSION

There are no easy solutions to the challenge of preventing atmospheric carbon dioxide increases if we go on burning fossil fuels. It appears that a multi-pronged attack of which conservation, energy management, afforestation and substitution of solar for fossil fuel are all parts of what is needed. The urgency of the energy problem is emphasised when we consider that if the whole population of the globe were to live at the energy consumption of the "big users" the primary energy consumption of humanity would increase five-fold. While this is not necessary (largely because the "big users" are also the big wasters) it is clear that with a doubling of the average energy standard of living and a doubling of the world population over the next 40 years we shall still face a 4-fold increase in energy use.

Were I a young chemist starting out on my career and wishing to do something exciting and useful I would certainly consider those aspects of my chosen subject that might be of significance to solar energy fixation in one form or another as a possible direction in which to go.

* * * * *

OBITUARIES

Professor James (Jim) O'Donnell

Professor O'Donnell died on 29th April 1995 in Brisbane after a courageous battle with cancer. While he will not have been known to all NZIC members, those involved in polymer science knew him as a primary force in the creation of the Pacific Polymer Federation, and certainly the driving force behind the RACI Polymer Division at the time that New Zealand became an integral part of the Division's activities.

As Professor of Physical Chemistry at the University of Queensland, Jim O'Donnell had a reputation as an innovative scientist with research interests that included the mechanisms of free radical polymerisation, solid state polymerisation, NMR characterisation of polymer structures, ESR of radical reactions and the degradation of polymers by high energy radiation.

Jim's organisational skills were evident in his many professional activities, having been Chairman of the RACI Polymer Division, National President of the RACI and more recently President of the Pacific Polymer Federation. It is in such roles that we knew him best and appreciated his commitment to detail and seemingly boundless energy and enthusiasm. The strength of these organisations he has left behind are fitting memorials.

Neil Edmonds
Polymer Group, NZIC

William Anderson (Bill) McGillivray

Dr William (Bill) Anderson McGillivray, who was Director of the New Zealand Dairy Research Institute from 1965 to 1979, died on April 2nd at the age 75.

Bill McGillivray, after being educated in Auckland and serving in the RNZAF, came to Palmerston North in 1946 as a junior lecturer in Biochemistry at Massey Agricultural College. He progressed to Head of the Biochemistry Department where his research interests were in the area of fat-soluble vitamins.

In 1959 he was appointed to the position of Chief Bacteriologist at the New Zealand Dairy Research Institute. He became Assistant Director in 1964 and Director in 1965, a position he held until 1979. During this period of rapid expansion at the Institute, Dr McGillivray was influential in directing its development to cope with the industry's quest for new overseas markets. From January 1978 until his retirement in 1980 he was seconded to the New Zealand Dairy Board as Resident Scientific Director and Liaison Representative for East Asia, stationed in Tokyo.

Dr McGillivray's distinguished academic career included the publication of over 100 papers on a range of scientific topics. After becoming Director at NZDRI he paid particular attention to milk quality and the nutritive value of milk and milk products. He received several prestigious awards such as a Nuffield Scholarship, the ICI Prize for Science and the Association of Scientists Science Medal. He was awarded the CBE in the Queen's Birthday and Silver Jubilee Honours List in 1977.

Dr McGillivray was elected a fellow of the Royal Society of New Zealand, an Honorary Fellow of the New Zealand Institute of Chemistry and a founder member and Honorary Life Member of the Society of Dairy Science and Technology. He was a keen advocate of New Zealand's participation in the International Dairy Federation and represented the country at many international dairying events. He was the New Zealand representative on the Commonwealth Bureau of Dairy Science and Technology and on the British Nutrition Society. He also served on the editorial boards of several international journals.

Following Bill's retirement, the McGillivrays resided in Tauranga. Bill retained his interest and involvement with the dairy industry, particularly in the matter of payment schemes for milk quality. He was an external director of the Rangitaiki Plains Dairy Company from 1981-85, prior to its amalgamation to form Bay Milk Products. He also remained the highly respected Patron of the Dairy Technology Society until its demise in 1993.

Palmerston North will remember Bill McGillivray as a city councillor from 1972-74, as a Justice of the Peace, a council member of the Palmerston North Chamber of Commerce, the Medical Research Council and as a director of the National Food Bank.

He is survived by his wife Betty and his two sons, Iain and Wilson.

* * * * *

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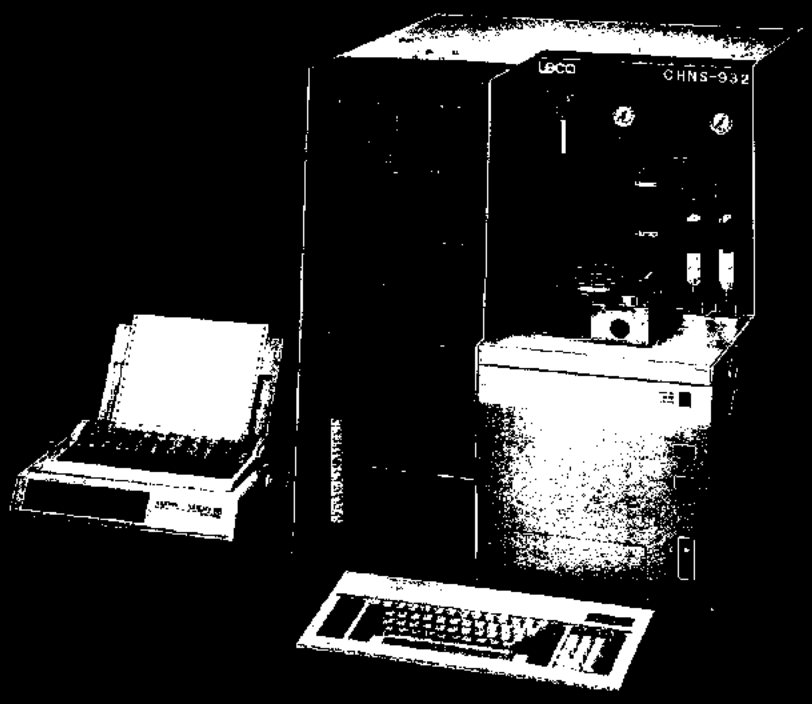

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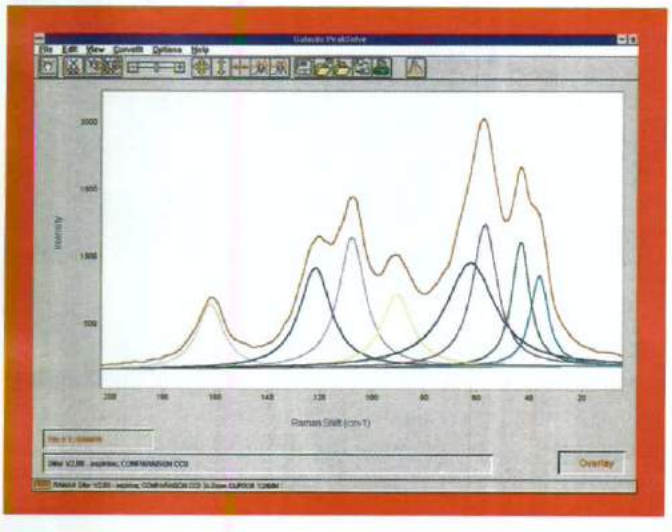

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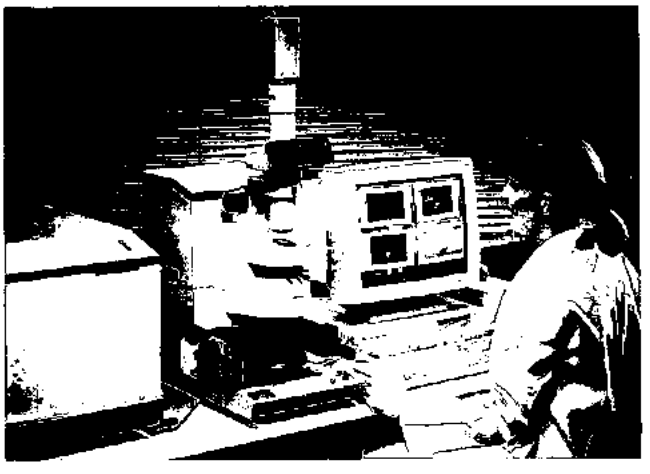

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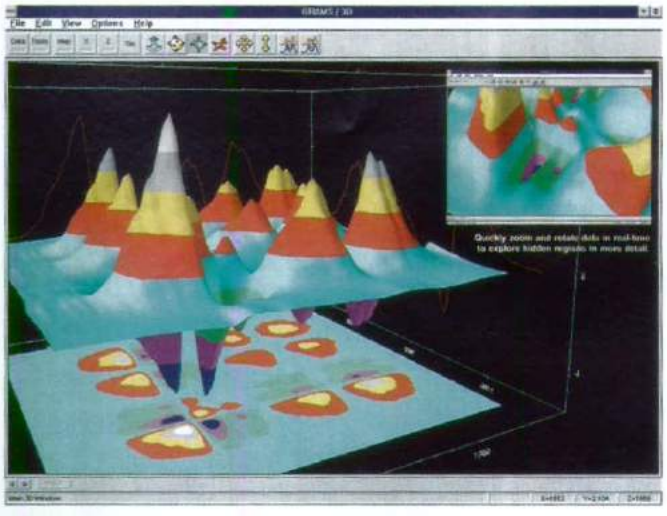

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Pooled water on drum heads is a problem that has plagued chemical storage for years. Not only does it cause drums to rust but water can leak inside and ruin expensive chemicals and lubricants, even worse it may cause severe corrosion with

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There is now a simple inexpensive solution for the prolonged protection of your drums from water related corrosion. DrumWick™ protects your drums and the environment with simple but amazingly effective technology.

DrumWick™ siphons water from the head of the drum over the drum lip at up to 2 litres per hour. Measuring just 30mm wide, the unique felt hydrophilic wick removes standing water using capillary action and gravity. DrumWick™ simply clips over the lip of a standard drum, and will give effective drum head siphoning for up to two years.

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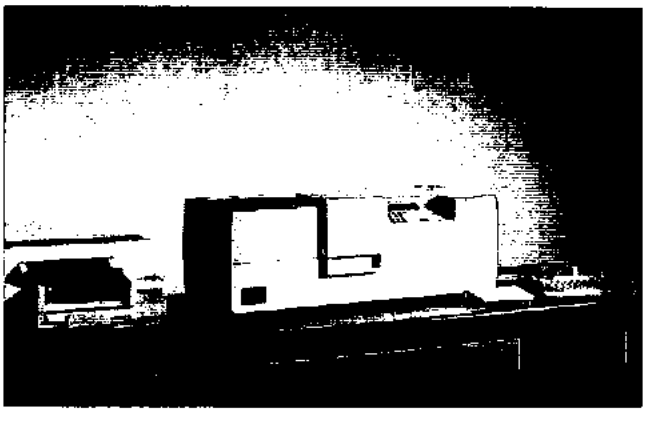
NEW POLARIMETERS FROM PERKIN-ELMER

Perkin-Elmer announces the introduction of the Model 341 line of polarimeters. Standing proudly in the tradition of well-reputed Perkin-Elmer precision polarimeters, the Model 341 introduces a new quality in polarimetric measurements.



In the Model 341 family of instruments, the proven optical null principle with automatic rotation of the analyser is combined with completely new state-of-the-art microprocessor electronics. That is to say, we have maintained the critical measuring system, which has been the basis of the excellent reputation of Perkin-Elmer polarimeters, while introducing multiple formats for results, an elegant user interaction, a printer report format meeting all GLP requirements, a comprehensive set of input/output ports, and many other attractive features. The new instruments therefore offer the highest possible accuracy and precision combined with simple operation and handling; and all that at prices which are substantially below the prices of the Model 241 instrument family which is now discontinued.

The instruments of the Model 341 line have the following attractive features:

• An attractive new design with an intergrated touch keypad and a vacuum fluorescence display (2x20 character).

• A motor-driven filter turret; the Model 341 is equipped with interference filters for 589 nm, 578 nm, 546 nm, 436 nm and 365 nm, and there are spare positions for 4 additional filters for UV lines of the mercury spectrum.

• Motor-driven apertures for standard cells and microcells.

• Multiple formats of results; you may display optical rotation, specific rotation, molar rotation, °Z of the International Sugar Scale, and concentration via a user-defined factor and offset.

• At the touch of a key you can display the available energy or the standard deviation calculated during the last integration period.

• A help function gives brief context-sensitive information (e.g. allowed range of parameters, etc.). User interaction is menu-oriented.

• A comprehensive set of input and output ports is provided for various peripheral instruments; this includes a Centronics port for a printer, an RS-232C port for a printer or a data system, a keyboard interface for an optional PC/AT keyboard and/or a barcode reader, an an analog output for a chart recorder.

• Inputs and outputs for control signals ("Polarimeter Ready" and "External Auto Zero") complement the extensive capabilities of the polarimeter.

• A complete analytical report may be generated for output to a printer or a data system; the report contains all information relevant for the measurement and thus meets all GLP requirements.

• Alphanumeric information related to the sample (e.g. batch number, sample name, solvent) may be included in the analytical report if an optional keyboard or barcode reader is connected to the polarimeter.

• Supported printers are Hewlett-Packard Laser Jet and DeskJet types, and Epson compatible printers; a straight ASCII output format allows you to print the results on most other commercially available printers.

• A real-time clock (with battery back-up) provides date and time for report printouts and monitors the operating hours of the source lamps.

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POISONOUS GAS HYPOTHESIS AS A PRIME CAUSE OF COT DEATH (SIDS)

A CHRONOLOGY OF EVENTS : TO FEBRUARY 1995

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6 March 1995

Mr Robert Lyon BSc MNZIC
Managing Editor
Chemistry in New Zealand
P O Box 12-909
Penrose
Auckland

Dear Mr Lyon

In the September 1994 issue of the Journal you kindly published a letter from me regarding the cause of cot death (Sudden Infant Death Syndrome).

I am sure you will find the enclosed chronology interesting but I do not know whether you would consider it appropriate for publication in the Journal. I had quite a degree of interest from members following the publication of the last letter, and this follow-up may be timely.

Yours sincerely

T J Sprott

ABBREVIATIONS

BAR = Dr Barry A Richardson, Winchester, UK, Consulting Scientist
PRM = Mr Peter R Mitchell, Marquee Manufacturer, Client of Dr Richardson
TJS = Dr T James Sprott OBE, New Zealand, Consulting Chemistry, Forensic Scientist
(NZ) = Occurred independently in New Zealand

1880s
Thousands of children die unexpectedly throughout Western Europe and in UK, adults are made ill, from mysterious cause. Problem is eventually solved by Italian chemist Gosio, who discovers it is due to a toxic gas, arsine and/or alkyl homologues generated by a micro-organism then known as *Penicillium brevicaules*, (now renamed *Scopulariopsis brevicaulis*). This acts upon green pigments (Paris Green and Scheele's Green) in wallpaper. Pigments are based on copper arsenate. Another source of arsenic is arsenious oxide used as a preservative in wallpaper glue. Gas is called "Gosio's arsenic".

1932
Last recorded case of fatal arsine poisoning in UK, from arsine generated by *S. brevicaulis* from arsenic in building blocks made from clinker arising from steel smelting.

1947
Mrs Clare Booth Luce, US Ambassador to Italy, is made unwell by arsine arising from point on ceiling of her bedroom in recently acquired Embassy building. Same mechanism of production.

Apr 86
(NZ) TJS postulates that SIDS is the result of unsuspected poisoning from a gas or gases generated by micro-biological activity within the baby's cot. Gas odourless or nearly so, denser than air and acts on the nervous system to inhibit breathing. TJS unable to suggest identity of the gas(es).

Sep 88
PRM consults BAR regarding failure of PVC marquee fabrics. BAR identifies cause: degradation of plasticiser in the PVC by fungi.

Dec 88
PRM consults manufacturer of PVC who suggests increasing concentration of arsenical biocide (OBPA) in PVC. BAR warns PRM of danger of arsine generation by fungi.

Dec 88
PRM contacts OPBA manufacturers and is told that OPBA is perfectly safe and that 'It is approved for use in cot mattresses".

Dec 88
(NZ) TJS completes some SIDS research in Southland, New Zealand, where the average rate over three years (1986/7/8) was 8.5/1000. TJS is concerned *inter alia* about organically bound nitrogen arising from the use of synthetic detergents (e.g. DDBS), foam stabilisers (e.g. LDE) and fabric softeners (QAs), all of which contain available carbon-nitrogen groups. These compounds represent a fundamental change from soap, which is virtually free from nitrogen. TJS advises parents to use soap instead of detergents for all baby-related laundry, in an intensive publicity campaign.

Jan 89
BAR institutes research to test his proposition regarding phosphorus, arsenic and antimony in mattresses. PRM requests mattresses of SIDS victims through Coroners. Many Coroners agree. BAR identifies *S. brevicaulis* on all sample mattresses; also the evolution of phosphine, stibine and (in one case from an "army mattress" arsine). BAR eventually checks over 200 such mattresses and demonstrates total correlation, viz: each SIDS victim's mattress is generating one or more of the gases.

Sources of the elements phosphorus and antimony are identified as originating primarily from fire retardants incorporated in foam mattress fillings and PVC mattress covers, as well as phosphorus compounds used as plasticisers in PVC. The arsenic in the army mattress arises from a biocide introduced for use in tropical climates. Trace amounts of arsenic occur in PVC containing antimony, apparently arising as an impurity in the antimony.

Jan 89
PRM studies SIDS rates for various sectors of the community and discovers that the SIDS rate amongst army personnel is over five times as great as for other married couples.

Feb 89
BAR advises Department of Health and Foundation for the Study of Infant Deaths of his findings. (Confidential communication).

Jun 89
BAR makes a media disclosure of findings about the toxic gases arising from bio-conversion of phosphorus, arsenic and antimony in cot mattresses into tri-hydrides. Recommends eliminating these from babies' environments. These recommendations are dismissed by conventional SIDS researchers but are taken seriously by some mattress manufacturers, who consult BAR.

Jun 89
BAR recommends that parents use a new mattress for each baby, alternatively old mattresses should be wrapped in polythene.

Jun 89
BAR recommends that babies should not be permitted to sleep face down, so as to avoid exposure to the gases (which are all more dense than air). This recommendation dismissed by the UK Chief Medical Officer.

1989
Several mattress manufacturers consult BAR and take steps to eliminate antimony - and phosphorus-based additives to mattresses, but do not make any public announcement of their intentions.

Sep 89
(NZ) TJS reports greatly reduced SIDS rate in Southland, to greater extent than expected, but cannot fully explain the finding (see Figure 1).

Dec 89
(NZ) SIDS rate for 1989 in Southland, New Zealand, drops from 8.5/1000 average to less than 2/1000, while rate elsewhere in New Zealand increases. In Auckland district rate is about 4.5/1000. TJS still unable to offer a cogent explanation for the dramatic reduction in Southland.

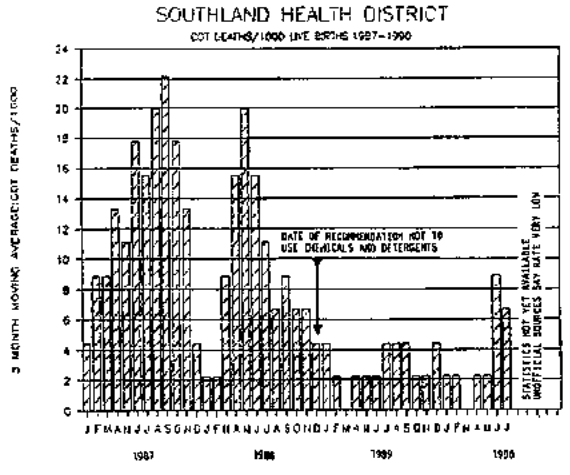

Figure 1: Southland Health District
Cot Deaths per 1000 Live Births: 1986-1990.

Mar 90
BAR publishes note in Lancet regarding bio-conversion of phosphorus, arsenic and antimony in cot mattresses into toxic gases, and suggests this as a prime cause of SIDS.

Mar 90
UK Chief Medical Officer sets up an Expert Working Group (Chairman: Professor Paul Turner) to investigate the hypothesis put forward by BAR and PRM.

Jun 90
BAR reports on his findings to a Joint Meeting of:
The British Society for Allergy and Environmental Medicine, and The American Academy for Environmental Medicine.

Jun 91
"Turner Report" published stating that Mr Richardson's findings and hypothesis could not be confirmed, but suggesting that antimony used for fire retardants should be free from arsenic.

(NOTE: the reason for non-confirmation of BAR's findings, especially as regards the generation of the gas(es) from mattresses was not understood at the time but BAR has now been able to explain. The Turner Group bio-chemists modified BAR's methods and thus reduced the sensitivity of the test method. They sometimes got a positive result and sometimes did not. Even their "spiked" sample tests were inconsistent. The explanation is that the test vessels were too large and allowed the tri-hydride gases to oxidise. The method of

detection depends on the reduction of salts of mercury and silver by the tri-hydrides, the so-called Gutzeit test).

1991
Army discontinues use of previous mattresses containing arsenic and replaces with new. Makes no announcement of this action. Unfortunately Army replaces the previous mattresses with mattresses containing antimony.

Nov 91
BAR publishes 60-page, 230-reference book "Cot Death - Must Babies Still Die?". This book was based on a three month investigation which was funded by Tomy Ltd., UK.

Nov 91
UK Department of Health introduces the "Back to Sleep" campaign, which recommends that babies not be permitted to sleep face down. Recommendation is based upon the NZ Cot Death Study, by Dr E A Mitchell and co-workers.

Nov 91
(NZ) BAR hypothesis regarding the tri-hydride gases is published in New Zealand but is dismissed by local SIDS researchers.

TJS realises that these findings provide the answer to his poisonous gas proposition and immediately contacts BAR. There follows an exchange of correspondence and visits by TJS to BAR.

1993
SIDS rate in UK has been falling steadily since June 1989 (see Figure 2). This fall became apparent two years before the commencement of the "Back to Sleep" campaign. It can only be accounted for by manufacturers and parents following BAR's advice in June 1989. Sales of new mattresses jumped by about 15% since 1989.

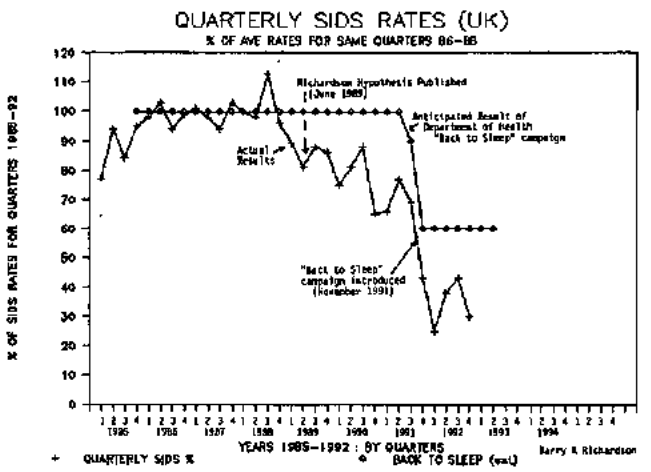

Figure 2: Quarterly SIDS Rates (UK): % of Average Rates for Same Quarters '86-'88.

1993
PRM obtains official statistics and prepares a revealing study comparing SIDS rates for 1st, 2nd, 3rd, 4th and subsequent children, also comparing with rate for unmarried mothers (Figure 3).

1993/4
Meditel (medical TV programme producer) researches topic for possible TV feature.

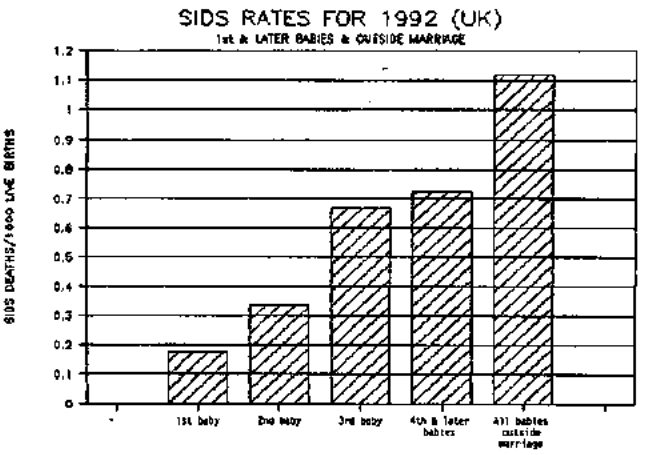

Figure 3: SIDS Rates for 1992 (UK): 1st and Later Babies and Outside Marriage.

Mid-94
Central TV accepts Meditel proposals and instigates research for the first Cook Report feature.

Nov 17/94
First Cook Report "The Cot Death Poisonings" screened. This correlated SIDS victims with post mortem samples tested for antimony and analyses of their mattresses (where available). There is an obvious link between tissue analyses for antimony and antimony found in the corresponding mattresses. Parents are urged to protect babies from the gas(es) by wrapping mattresses in thick polythene, secured firmly underneath mattress with adhesive tape.

Nov 18/94
UK Chief Medical Officer and other authorities dismiss the findings labelling them as alarmist. Polythene recommendation is opposed.

Nov 18/94
BAR and TJS suggest that Cook Report investigate living infants by analysing hair for antimony and compare with mother's hair. Very great differences found in some instances, indicating infants have been exposed to antimony. Antimony chosen as normally people have only minute amounts of antimony in their hair. Many (but not all) infants have from 20 to 100 times as much antimony in their hair as their mothers have. The antimony can only have reached their bodies as a gas from their cots. A link is found between such babies and their mattresses, when later analysed for antimony.

Nov 30/94
Chief Medical Officer sets up second Expert Group to investigate Cot Death Theories and findings of Cook Report; Chairperson is Lady Limerick.

Dec 01/94
Cook Report "Cot Death II" screened with this information and other information about the effects of antimony in living persons. Recommendation about wrapping mattresses repeated and example screened.

Controversy continues in UK but some qualified people privately agree that the proposition is correct, or has great merit.

UK Foundation for Study of Infant Deaths affirms polythene wrapping recommendation, qualified by the words "...if parents are worried..".

Dec 94
Scottish Foundation for the Study of Infant Death adopts mattress wrapping recommendation with the same proviso. Other official organisations do the same.

Dec 94
BAR provides probable explanation for TJS finding in 1989 in Southland, NZ (SIDS rate reduced by 80%). *S. brevicaulis* requires source of nitrogen to flourish. Laundering with soap denies *S. brevicaulis* a ready source of nitrogen thus inhibiting growth.

BAR also explains that *S. brevicaulis* probably ingests phosphorus, arsenic, and antimony compounds (mistaken for nitrogen which is the same Group (V/Vb)(Group 15), and the atomic radii of the three elements are almost the same). To eliminate the unwanted elements *S. brevicaulis* converts them to the gaseous tri-hydrides and expels them.

NOTES:

1) BAR's hypothesis explains and is compatible with every known factor regarding SIDS. It explains the various observations made by epidemiologists. In addition to the Tomy Report BAR has published several papers and letters on this hypothesis in technical literature.

2) In particular the BAR hypothesis explains the success of the "Back to Sleep" campaign, but demonstrates that this advice does not prevent SIDS. Supine sleeping only reduces the risk (toxic gases are more dense than air so flow away from a baby sleeping face-up).

3) This proposition also explains the finding that over-hot babies are more at risk since the increased temperature greatly increases generation of gas. BAR states that a temperature rise from 37°C to 40°C will cause gas generation to increase by up to 20 times.

4) Any source of the elements is accessible to the fungus and the elements occur naturally in many natural substrates. This accounts for the observation that cot deaths were known (albeit in far fewer instances) before the present styles of mattress were introduced.

5) The toxicity of the gases is extremely high, about 100 times that for hydrogen cyanide. The estimated lethal dose for stibine, for example, is about 1mg m^{-3} for 30 minutes exposure.

6) The prime mode of action of the gases is to interfere with the cholinesterase function thus inhibiting breathing and heart function. Other supplementary functions are explained by BAR in the Tomy Report.

7) When considering the toxicity of these tri-hydride gases it must be understood that they are much more toxic than any other compound of the same elements. Thus the normal toxicity data are not relevant.

8) For technical reasons it is not possible to track phosphorus and arsenic in the body for possible poisoning from phosphine or arsine, but antimony can be clearly identified and used as a measure of abnormal contamination, as normally there is only very little antimony in the body, other than in persons having had high exposure.

9) The longer term effect of residual phosphorus is probably not very significant. All the gases are quickly oxidised in the body and antimony converts to antimony trioxide (Sb_2O_3). The fate of arsenic seems more obscure.

10) There is no doubt that infants exposed to stibine accumulate much more antimony that do their mothers, as evidenced by the excretion of antimony in the hair. Just what this exposure means in the longer term is not clearly known. In this connection it should be remembered that the Sb_2O_3 formed from stibine, SbH_3, is in the finest possible state of subdivision, being derived from the decomposition of a gas. It is well known that very finely divided solids are the more active, due to the greater surface area of the particles.

11) BAR's publications suggest other fire retardants which are quite safe and very effective.

12) There is no need to use phosphorus - and antimony-based compounds in a baby's environment and the addition of any such compounds to a baby's mattress should be banned forthwith.

PROPOSED SPECIFICATION FOR COT MATTRESSES

S1) No amount of any compound containing any phosphorus, arsenic or antimony should be added to any component of any mattress intended for use by infants.

S2) When tested by the standard analytical methods there shall be no detectable phosphorus, arsenic and antimony.

S3) The lower limits of detection should be stated in the analytical report and preferably should not be greater than:

0.001% = 10 mg/kg = 10 parts per million.

S4) Any claim made by a manufacturer that any cot mattress meets this requirement should be supported by an analytical report to this effect from a recognised analytical laboratory.

NOTE: Cot mattresses conforming with the above Specification may display the *Campaign against Cot Death* logo (refer B A Richardson).

SUMMARY

a) A potential prime cause, indeed probably a major cause of SIDS has been elucidated.

b) The exposure of infants to the tri-hydride gas(es) has been demonstrated beyond any reasonable doubt.

c) Calculations carried out by BAR and TJS show that a toxic concentration of one or more of the gases within the baby's cot is to be anticipated.

d) The argument that babies have died from this source of poison is unassailable.

e) Further research is clearly indicated, especially into the long term effects from residual arsenic and antimony in children's bodies, but this is certainly not the first priority.

f) There is an urgent need for supplies of mattresses known to comply with the attached draft specification.

g) Until such mattresses are available, parents should be urged to adopt the recommendation to wrap cot mattresses securely in heavy-grade polythene sheet, fastened underneath with strong adhesive tape.

h) Whether or not the SIDS proposition is accepted, many children in UK are assimilating antimony in their bodies. Antimony is not an essential element and is clearly undesirable. Some means of avoiding this hazard is very urgent. Wrapping with polythene is the only option in the immediate future.

i) For these reasons alone we urge that all official bodies endorse the recommendation that all existing mattresses should be wrapped.

j) The statement by the Chief Medical Officer that antimony is common in the normal environment is quite incorrect.

k) Polythene does not contain any harmful substances and inhibits both flow of the gas(es) and growth of the fungus.

l) The allegation that polythene used in this manner is dangerous is without substance, provided that the polythene is firmly secured by strapping joints in the polythene beneath the mattress with strong adhesive tape.

m) Likewise the statement that this procedure will result in the baby becoming overheated cannot be sustained.

n) BAR and TJS recommend that any cot mattress should comply with the Proposed Specification for Cot Mattresses.

o) Cot mattress manufacturers whose products meet this specification are encouraged to adopt the logo of the *Campaign against Cot Death*. Applications to do so should be made to B A Richardson.

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What follows is a copy of the NZIC submission to the Select Committee on the Hazardous Substances and New Organisms Bill - *Ed.*

SUBMISSION

To the Select Committee on the Hazardous Substances and New Organisms Bill

Introduction

1. This submission is from the New Zealand Institute of Chemistry (NZIC) in the name of its President, Professor W A Denny, P O Box 12 347, Wellington.

2. The New Zealand Institute of Chemistry is the only professional body in New Zealand for practising Chemists and Biochemists. Its grades of membership provide for public recognition of the status in which professional chemists are held. Throughout its sixty five year history, NZIC has promoted the safe handling, storage and use of all chemical substances and hazardous materials in a manner commensurate with industrial harmony and environmental safety.

It is in light of these attributes that we make our submission.

General

3. The New Zealand Institute of Chemistry (NZIC) is the professional body in New Zealand promoting the development of chemistry and the proper management and safe use of potentially hazardous chemicals. It believes that legislation controlling hazardous substances should be comprehensive and consistent and should incorporate a precautionary approach which applies throughout the full lifecycle of such substances, from the time of its importation or manufacture until that of its transformation into a nonhazardous form or final safe disposal.

4. It is recognised that the Bill indicates the general philosophy, structure and method of control proposed for the Act and that detailed provisions will be indicated in subsequent regulations. In this respect we have found the discussion paper on proposals for regulations provided by the Ministry for the Environment particularly helpful. This submission therefore is directed solely at matters in the Bill. It is anticipated that opportunities will be provided to comment on proposed regulations as these are being developed.

5. The NZIC supports the intent of this Bill because it strengthens existing legislation for the control of hazardous substances and underlines a need to have appropriate management controls for both new chemicals and new organisms. However, we are concerned about the resource implications of the Bill as they will impact on government agencies, industry and educational institutions.

6. We are also concerned about the establishment of a new bureaucracy (ERMA) to administer the provisions of the Bill. To achieve the stated aims of the Bill, ERMA runs the risk of becoming a large, unwieldy organisation. We are concerned that there may be insufficient technical and scientific expertise available to administer the procedures required without a major diversion of resources from mainstream scientific and technical activities.

7. We are concerned that this Bill does not cover the hazards associated with radioactive substances and ionising radiation. While this is covered by other legislation, we see no reason for this exception given that the stated aim of the legislation is "to apply the principles of sustainable management of the environment to hazardous substances and new organisms". Radioactive substances are manifestly hazardous.

8. We note that the Bill does not cover infectious substances. As substances likely to cause diseases in humans, control of their general use obviously comes within the scope of public health legislation. However there are stages in the life cycle (e.g. importation, storage, transport and disposal) during which they should come under the control of ERMA. This is particularly relevant to biological samples being sent for testing. The UN Recommendations on the Transport of Dangerous Goods specify packaging labelling criteria and transport procedures. The control of infectious substances is analogous to hazardous substances which are medicines, and therefore should be included in the Bill.

9. We are also concerned that because of its broad nature, this Bill bestows upon ERMA many functions that are presently conducted by other agencies, institutions or individuals. Thus there are dangers that continuity of expertise may be lost to ERMA and that efforts will be duplicated.

10. We note that the first sentence of the Explanatory Note to the Bill states "The aim of Hazardous Substances and New Organisms law reform is to provide a comprehensive and consistent approach to the management of hazardous substances and new organisms". This objective should be included in Clause 4 which outlines the purpose of the Act. This change would support Clause 8(g).

Eco-toxicity and Environmental Management

11. We support the extension, in this Bill, of legislation covering hazardous substances to their effects on the environment. However, we are concerned that the specific powers of ERMA with regard to environmental risk assessment are not proscribed by the Bill. Clause 8(c) empowers ERMA to "monitor and review systems for meeting obligations under this or any other Act". Presumably this includes the Resource Management Act. Will ERMA become a New Zealand version of the US Environmental Protection Agency with all its bulk, expense and mistakes?

12. Clause 89 empowers ERMA to levy environmental user charges having regard, amongst other things, to "the costs of monitoring". Does this imply that ERMA will set up an environmental monitoring agency, or contract out such work?

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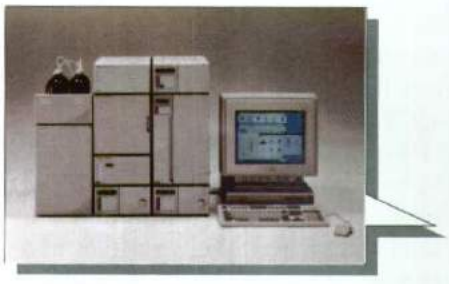

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This not only conflicts with the statutory role of regional authorities under the Resource Management Act, but also places ERMA in the dual role of being both policy-maker (developing the regulations and guidelines) and enforcer. The conflicts of interest are obvious.

13. The experience suggested by hearings for environmental consents suggests that overseas eco-toxicity data may not be accepted as sufficient proof for hazard assessment in New Zealand. Thus, eco-toxicity testing may have to be carried out on thousands of chemical compounds since it is proposed that all hazardous substances in this category be subject to tracking procedures. We are concerned that New Zealand does not presently have the resources for testing on this scale.

Specific Comments

Clause 2

14. Stationary container: This definition would appear to include a building. Is that the intention? In relation to some industrial processes problems may arise in applying such definition to containers used in the processing of chemicals as the nature of the contents may change.

15. Toxic: Problems may arise from the wording of this definition as it implies established effects on human beings. Often the only toxicity data available will be that derived from the effects on animals.

Clause 8

16. With regard to paragraph 7 above, Clause 8(c) "To monitor and review systems for meeting obligations in respect of hazardous substances under this or any other Act:" would seem to empower ERMA to consider radioactive substances except that the definition of "hazardous substances" in the Bill does not explicitly include such substances. The essential source of hazard from radioactive substances is the radiation they emit.

17. Clause 8(e) states that ERMA shall "promote increasing public awareness of matters relating to hazardous substances...". This is one of the key functions of NZIC.

18. Clause 8(i) directs ERMA to "contribute to the work of international authorities as directed by the Minister". At the present time, these functions are largely coordinated by the Royal Society of New Zealand and its member bodies such as the NZIC through the national committee system. We believe that this system should remain, and is best ensured by having direct NZIC representation on ERMA.

Clause 10

19. We consider that between 5 and 7 members is wholly insufficient to cover the ranges of expertise implied by 10(2). The suggested composition allows for at most 2 technical experts to cover a broad range of scientific knowledge: fire and explosion safety, corrosion, human toxicology, biology and environmental effects.

20. There is some provision in the First Schedule for the establishment of advisory committees. It is essential that the accumulated knowledge of existing institutions is not lost, particularly during the transition phase of the establishment of ERMA.

21. NZIC, as the national professional body representing chemistry and the chemical industry, should be asked to nominate members of ERMA.

Clause 15

22. It is suggested that some moderation of charges may be appropriate, particularly for small scale activities, so as to ensure that there is no significant financial disincentive acting against notification. It is also recommended that Clause 15 be amended to allow a low registration fee with the bulk of ERMA's funding being derived from a levy or toll per unit on all hazardous substances imported or manufactured in New Zealand. This would also have the advantage of having funds available for assessments. It would be expected that a significant proportion of requests for reassessment will come from private individuals, conservation or environmental groups who do not have the same financial resources as corporations. Another advantage of a toll/levy scheme is that during the initial introduction of a product the regulatory costs would be low. If the product is a success then volumes will increase and the financial contribution will also increase.

Clause 19

23. Many substances are likely to be widely used by different persons or institutions. There should therefore be some provision for streamlined applications in the case of substances already approved for use by other persons. Specifically, information listed under 19(2)(c) need not be repeated.

Clause 20

24. We cannot see the distinction between Items (b) and (c) of this clause.

Clause 22

25. The meaning of "Small amounts" in Clause 22(a) is vague. A small amount for "use as an analytical standard" can range from less than a milligram to several hundreds of grams. Some guidelines are needed here.

26. The meaning of "research" in Clause 22(b) is equally vague. Does this mean "research in an approved institution", as prescribed in Clause 25, or does it mean something less than that?

27. The provisions of Clause 22(a) and (b) appear to overlap with those of Clause 25 and should be combined.

Clause 25

28. Clause 25 (1) (a) permits the small-scale use of hazardous substances in scientific investigations or teaching if the laboratory meets "performance standards". We do not understand the meaning of the term "performance standards" - presumably these are standards relating to laboratory safety. We consider that the wording of 22(a) should be replaced with the concept that a suitable laboratory is one which would receive approval to import or manufacture substances of the highest toxicity.

29. It is suggested that additions be made to Clause 25 to provide for ERMA to keep a register of all organisations wishing to use this exemption, and, requiring each organisation to nominate a person responsible for compliance in each laboratory or research unit.

30. Clause 25(b) requires that "the experiment does not create or use a substance for which an application for approval has been declined". We consider this clause to be wholly impractical. Firstly, it requires that scientists be aware of all substances that have been so declined. Secondly, it requires that scientists know in advance what substances will be produced by their experiments, which is often not the case and usually contrary to the whole point of the experiment.

31. Clause 14 requires ERMA to keep a register of all applications made to the authority and Clause 14(d) requires this register to record if the application was approved or declined. Clause 14 (5) requires ERMA to make the register available to every person during normal office hours. In the event of a dispute this register will be the definitive listing. Scientists do not necessarily work "ordinary office hours". If the "official list" of declined substances is only available at ERMA offices, it will be impracticable for scientists to be aware of what has been declined. The "official list" should be made readily available electronically 24 hours per day, 365 days per year. Currently all universities and research organisations have access to Internet. Many commercial organisations have or are intending to gain access to similar electronic media. An electronic listing by ERMA would therefore have considerable advantages. We request that the Bill make provision for this.

32. In the same way, the preliminary section of the Bill (Clause 2) defines "manufacture" to include "mining and extraction" of any hazardous substance. One of the specific aims of research in natural product chemistry is to extract unknown chemical substances from plants and animals with the aim of finding new chemical materials that are toxic and therefore have potential as drugs, e.g. for anti-cancer, anti-bacterial or anti-viral activity.

Clause 45

33. New Zealand should reserve the right to prevent any non-approved hazardous substances from transiting our territorial waters (preferably our economic zone) without prior approval. The Basel Convention 1989 for example requires prior informed consent for red tier substances. There are also considerable controls on yellow tier substances. We should know what is entering/transiting our territorial waters so as to allow appropriate emergency response planning.

Clause 46

34. The 10 day period for ERMA to decide to seek further information may be too short. In most cases a full assessment of the information supplied would need to have been done before deficiencies could be established. The issue is not whether the applicant can provide more information (which the authority may not be in a position to judge), but whether more information is needed for the application to be adequately assessed.

35. We would suggest that consideration be given to an alternative assessment scheme which would streamline the process considerably. ERMA should carry out a preliminary risk assessment based on the information provided by the applicant and from other sources available to ERMA. It could also advertise for data relating to the substance involved. Once this preliminary risk assessment has been carried out, ERMA could draft proposed controls with a degree of public involvement. These would then be published and submissions on these called before finalising the controls imposed. In this way there would be adequate opportunity for public involvement and a balance would be achieved between science and public expectations.

Clause 47

36. ERMA should have the power to extend the closing date for submissions as limited by Clause 47(3)b. It is possible that 30 working days may not provide sufficient time for interest groups to research the facts or obtain data necessary to support their view.

Clause 49

37. This clause appears to give proprietors of medicines and pesticides an unfair advantage over those for other hazardous substances. All hazardous substances should be treated in the same way. This Bill requires data to be provided to the Authority for regulatory approval. The spirit and intent of Article 39 of Annex 1C of the GATT Agreement should be applied to all hazardous substances, not solely to medicines and pesticides.

Clause 58

38. Where a person holds stocks of a hazardous substance for which approval was previously granted in the normal course of events, and approval is subsequently removed by ERMA after reassessment, it seems manifestly unfair that the owner should have to meet the disposal expenses. Such disposal should be funded by ERMA, e.g. from fines imposed on users who unlawfully breach the regulations.

Clauses 60 and 61

39. The inclusion of this "catch-all" clause which is able to circumvent the purpose of the Bill implies that occasionally there will be factors affecting the decision to approve use of a substance or organism that cannot properly be assessed by ERMA. In our opinion, the provision in Clause 62 to obtain additional expertise, should adequately cover such situations.

Clause 67

40. Clause 67(2) implies that the regulations arising from this Bill will override those of any other Act unless specifically provided for. This would imply that control of radioactive substances also comes under the provisions of HSNO, notwithstanding existing legislation.

Clause 100

41. Maximum penalties as indicated in the Bill appear too low when compared with those provided in similar legislation such as the Resource Management Act 1991.

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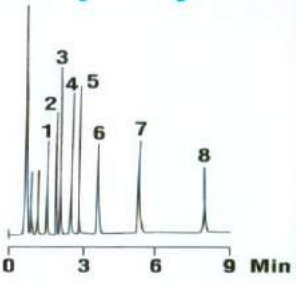

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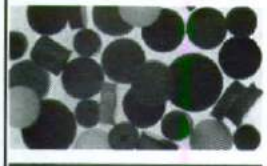

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42. Failure to notify significant new information (Clause 99i) or failure to obtain a transferable permit (Clause 99h) both have the potential to be as damaging or harmful as failing to obtain approval, thus the maximum penalties for these offences should be the same as for those specified in Clause 99 (a), (b), (c), (d), or (e).

43. Failure to comply with a compliance order could give rise to damage or injury equivalent to serious harm under the Health and Safety in Employment Act. There may however be such situations which are not covered by that Act. Consequently the penalty for an offence against Clause 99 (c) should be comparable with the penalty (maximum $100,000) for "knowingly cause" as covered in Section 49 of the Health and Safety in Employment Act. While acknowledging that there is provision in the Bill for an ongoing penalty, we believe that the maximum penalty for this type of offence should be a fine of $50,000, and if the offence is ongoing a further fine not exceeding $5,000 per day, would be more appropriate.

44. Failure to comply with Clause 110, which is an offence under Clause 99 (g). This is likely to be a once-off type of offence and unlikely to be a continuing one. Consequently the maximum fine for this offence should be higher, say $25,000, with the fine for an ongoing offence reduced or removed.

45. The penalties for obstruction (Clause 99 k) appear to be too low. As obstruction could be used to prevent evidence being gathered for a more serious offence, a compliance order or declaration of an emergency, the penalty for this offence should be substantially increased. We believe a maximum fine of $25,000 would be more appropriate.

Clause 102

46. This clause should be extended to include offences resulting from actions about which Directors and Officers ought to have known. This would put more onus on managers at all levels to be informed and take responsibility for hazardous substances.

Clauses 121-125

47. These clauses define the powers, duties and responsibilities of "enforcement officers". At no point is the requirement for expertise in respect of either hazardous substances or organisms either mentioned or required. We consider that the exercise of "good faith and reasonable care" (Clause 125) depends entirely on having sufficient technical expertise to understand the emergency at hand. In this respect we consider that basic police training is unlikely to be adequate. Is the intention that police officers can act only in respect of emergencies (Clauses 121 - 125) but that 92(1) applies in all other situations?

First Schedule

48. This Bill will have serious implications for the normal operations of both educational and research organisations. Both use a vastly wider range of different chemical substances and organisms than industry or agriculture. We consider it essential that a practising scientist from both a university and a Crown Research Institute be appointed to the Authority to provide the necessary expertise.

Seventh Schedule

49. There are a number of errors in the list of substances subject to the transitional provisions. This list should be scrutinized by persons with expertise in chemistry.

Concluding Comments

50. The New Zealand Institute of Chemistry supports the aims and objectives of this Bill and the comments made above are intended to assist in achieving clarity and consistency from amendments resulting from the deliberations of your committee.

51. Within the membership of the Institute there is considerable expertise in chemistry and the management of chemical hazards. This expertise will be used to assess and comment on further development of this law reform, particularly during the development of detailed regulations.

52. The Institute is willing, within the limitations of its resources, to further assist during the development of this legislation should this be required. We would also be willing to recommend suitably qualified people for membership of ERMA and any advisory committees.

53. We expect to continue to be active in the promotion of the activities of ERMA and the implementation of the Act and Regulations once these come into force.

* * * * *

MINISTRY FOR THE ENVIRONMENT

CONSULTATION ON MANAGEMENT OF ORGANOCHLORINE WASTES

* REGISTRATION OF INTEREST
* INFORMATION ON DESTRUCTION TECHNOLOGIES

The Issue

The past use of organochlorine (OC) substances in New Zealand such as aldrin, dieldrin, chlordane, DDT, pentachlorophenol (PCP), and PCBs has led to a number of present day concerns, including:

- a number of dieldrin waste dumps;
- contamination of soils and materials where OC substances have been manufactured, used or spilt;
- quantities of OC hazardous wastes and redundant chemicals;
- persisting DDT resides in soils in some areas;
- some evidence of environmental contamination;
- residual PCBs.

OC wastes, if not safely managed, may continue to pose risks to human health and the environment.

Current Activities

- several regional councils have collected redundant agricultural pesticides from farms including DDT, dieldrin and aldrin. These wastes are presently being held in secure storage pending an appropriate destruction technology;

- investigations at some sawmills have found PCP (and dioxins in some circumstances) in dust, soils, sawdust, treatment sludges and building materials;

- the Ministry of Health is facilitating the collection and disposal of PCBs;

- the Ministry for the Environment (MFE) is reviewing the role of the Government with respect to OC wastes;

- the MFE, as part of the development of contaminated sites policy, is working with the Timber Industry Environmental Council (TIEC) in researching the task of clean up and disposal of PCP and dioxin contaminated material;

- the MFE is monitoring the current US EPA review of the assessment and significance of dioxin and related compounds in the environment.

Proposed Consultation

OC waste problems are complex, there are uncertainties about which destruction technologies to use, and the level of public concern warrants a careful evaluation of the problems.

The Ministry for the Environment therefore proposes to carry out a programme of public consultation so that cost effective solutions for managing OC wastes, including their destruction, can be employed with confidence and in a coordinated way.

The Consultation Process

The Ministry for the Environment proposes to convene a Steering Group of representatives of interested parties to plan the consultation programme. The Group will provide guidance to the Ministry on information needs and the consultative process that will lead to decisions on questions such as:

- Are the technologies "safe"?;
- What other waste management options could be considered? (e.g. export, containment);
- What economic, social and administrative factors need to be taken into account?

The Ministry will:

- Make copies of reports available;
- Hold public meetings/fora as necessary;
- Provide an opportunity for submissions, take views into account in decision-making and provide feedback to all interested parties.

Expected Outcomes of Consultation and Further Research

- Public understanding of the relative pro's and con's of leading technology options, with access to technical information as required;

- Identification of Resource Management Act consent requirements;

- Identification and resolution of issues of public concern;

- Government policy and a management plan for OC wastes.

Information on Destruction Technologies

The technology most widely used overseas to destroy OC wastes is high temperature incineration. However there is a worldwide interest in alternative technologies. The MFE and the TIEC commissioned two separate consultants to report on a scientific review of technologies able to destroy PCP, dioxin and other OC wastes.

The reports are of a technical nature and not likely to appeal to a non specialist audience. To make the essential information more widely available, an executive summary of each report has been prepared. A copy is enclosed for your information. For those who wish more detail, copies of the two reports are available from the Minisfry for the Environment, either for loan or for purchase. Copies can also be viewed at the offices of any Regional, City, or District Council.

Potentially Interested Groups

Farmers, the chemical industry, sawmillers/timber treaters, regional councils, territorial local authorities, hazardous waste contractors, farm and horticultural workers, the chemical and wood industry workers, government agencies, the scientific community, environmental consultants, environment, iwi and community groups.

If you have an interest in this issue, copies of the form to request further information and/or to facilitate the planning of the consultation programme, are available from the Editor, *Chemistry in New Zealand.*

EXECUTIVE SUMMARY I

1. Background

In New Zealand, chemical treatment has long been used for the preservation of timbers. Pentachlorophenol (PCP) was used for an extended period of time before being withdrawn during the 1980s. PCP has been used in the form of sodium pentachlorophenate (Na-PCP) as an anti-sapstain fungicide for the temporary surface protection of sawn timber and this was often in conjunction with boron treatment. This treatment method was an aqueous phase process and was widely used. PCP was less widely used in a hydrocarbon oil carrier for the permanent protection of timber. PCP and Na-PCP mixtures will typically contain other chlorinated phenols and dioxins and furans as undesirable byproducts formed during PCP manufacture.

CMPS&F Pty Ltd (CMPS&F) was engaged by the Timber Industry Environment Council and the Ministry for the Environment to undertake a review of the options for destruction of pentachlorophenol (PCP) wastes generated by the past use of PCP.

2. Purpose of Study

The primary objective of the study was to identify the best practical treatment option or options for the management of a wide range of PCP containing waste materials. The review was based on information available in the published literature and on information obtained through direct contact with technology vendors and others that may have experience in the implementation of such technologies. Throughout the study emphasis has been placed on processes which are fully demonstrated and proven, destroy rather that contain waste, and may be readily established in New Zealand if approved.

The second objective was to report on the applicability of the technologies to treat other organochlorine wastes.

3. Study Methodology

The overall study has been undertaken in four stages, as follows:

- Identification of possible treatment technologies
- Technology Screening and Shortlisting
- Detailed Evaluation
- Selection of Best Practical Treatment Option (BPTO)

4. Technology Types

A wide range of technologies are available or are potentially available for the destruction of PCP contaminated waste materials, but this review has focused primarily on technologies that are commercially available. A brief description of each of the technology types is presented in the report.

Consideration was given to:

- the status or commercial availability of the technology;
- the overall costs of clean-up;
- the amount and type of residuals produced;
- whether the process destroys or merely immobilises the contaminants;
- the effectiveness of the process;
- the range of wastes to which the technology may be applied;
- the level of technical support available; and
- the safety and risk posed to the environment and people by the process.

5. Evaluation of Treatment Technologies

5.1 Overview

A brief summary of those technologies ranking highly as part of the final consideration of the BPTO is presented in the following sections.

5.2 Incineration

Incineration treats organic contaminants in solids and liquids by subjecting them to temperatures typically greater than 600°C in the presence of oxygen, which causes volatilisation, combustion and destruction of these compounds. The primary stages in the incineration process are waste preparation, waste feed, combustion and off gas treatment. Waste preparation can include shredding of bulk waste materials to achieve a uniform feed size. The primary factors affecting the performance of incineration systems are the temperature, time, and turbulence within the combustion zone. Combustion gases from the incinerator are treated by air pollution control equipment (such as bag filters) to remove particulates and neutralise acid gases. In order to ensure adequate destruction of chlorinated substances, temperatures in excess of 1200°C and detention times of more than 2 seconds are usually required, with careful handling of the off gases to avoid reformation off dioxins on cooling.

There are a wide range of incineration technologies, each with particular advantages and best suited to different waste types and waste volumes.

5.3 Chemical Dehalogenation

Chemical dehalogenation includes technologies such as Base Catalysed Decomposition (BCD), alkaline metal hydroxide/ polyethylene glycol (APEG) and potassium metal hydroxide/ polyethylene glycol (KPEG). Of these processes, BCD is now the most commonly used and the most practical for treatment of large volumes of contaminated soil.

The BCD process involves the use of a base (e.g. NaOH and $NaHCO_3$), a catalyst, and an aliphatic hydrocarbon oil as a hydrogen donor. The BCD process is designed to fully dechlorinate contaminants such as PCP and dioxins. A number of approaches have been used in the application of the BCD process, including;

- Addition of the reagents directly to the soil (approximately 10% by weight), following screening and crushing of the soil, and the heating of the soil mixture in a rotary reactor at 350°C for approximately 1 hour.
- Use of thermal desorption to remove contaminants from the soil or other solid matrix, followed by treatment of the extractant using BCD.

5.4 Chemical Reduction Processes

The Eco Logic process involves the reaction of contaminants with hydrogen at a temperature of approximately 850°C to give a waste gas stream containing hydrogen, nitrogen, methane, carbon monoxide, water vapour, other light hydrocarbons and, in the case of organochlorine wastes, hydrochloric acid (subsequently removed in the off gas treatment system). The Eco Logic process has been applied to a range of waste streams by varying the preprocessing units used in conjunction with the main reaction unit. In particular, contaminated soils have been treated using a purpose designed thermal desorption unit,

employing a molten tin bath, to remove the contaminants from the soil, with the generation of a gas stream containing the contaminants which can be treated in the gas-phase chemical reduction unit.

The Eco Logic process is relatively flexible and can be used to treat a range of organic contaminants (including both chlorinated and non-chlorinated waste materials), and a range of different waste types including PCP, although some prepossessing (e.g. size reduction) may be required. The Eco Logic process is able to treat soils and sludges with a significant moisture content without predrying, as water is required as a source of hydrogen for the process.

5.5 Ultraviolet Radiation and Oxidation

The degradation of organic compounds exposed to sunlight is well documented and there are currently a number of processes employing ultraviolet (UV) light enhanced degradation, particularly for the treatment of aqueous wastes.

UV light has been used successfully, in conjunction with chemical oxidants such as ozone or hydrogen peroxide, for the treatment of aqueous waste streams containing organic pollutants. In particular such technologies have a demonstrated capability of degrading PCP and dioxins, being able to achieve effluent concentrations below those required for discharge to surface waters. The performance of such units is a function of the detention time in the reactor, the intensity of the UV light and the dosing of ozone and/or hydrogen peroxide, and the design requirements are usually determined by pilot trials. Typically such a unit is available mounted on a skid and therefore may be regarded as transportable; however, ancillary equipment such as holding/balancing tanks may have to be constructed at the site.

In general the process has been used widely around the world, with one such process having been installed by Forestry Corporation for the treatment of PCP contaminated groundwater from the Waipa Processing Complex.

6. Determination of the Best Practicable Treatment Option

The various destruction technologies are assessed in the report and rankings for treatment of the various waste streams applied. The rankings have been based on scenarios which are considered to be typical as to what might apply for each treatment technology if it were selected as the preferred treatment technology.

The relative rankings of each technology have been based on CMPS&F's judgement, and in practice the ranking can vary

Table 1
Ranking of Practicable Treatment Options

Contaminated material		Overall Ranking	
1.	Concrete, drains, rocks, gravel, soil	1A	Contaminated Soils, heavily contaminated material: BCD (T) > Eco Logic > Rotary Kiln, Plasmox, Fluid Bed.
		1B	Surface contaminated concrete, rock, gravel, timber, metal: Surfactant wash, washwater and sludge treated, cleaned debris to landfill.
2.	Pure PCP	2A	If treatment facility exists for other wastes then all would be similar.
		2B	If dedicated facility, then BCD > Eco Logic > Rotary, Kiln, Plasmox, Fluid Bed.
3.	General Waste Gloves, Respirator Cartridges, Overalls, Plastic Wrapping etc.		BCD (T) > Eco Logic > Rotary Kiln, Plasmox, Fluid Bed.
4.	Sludge		Eco Logic (T), BCD, > Rotary Kiln, Plasmox, Fluid Bed.
5.	Oil		BCD > Eco Logic > Rotary Kiln, Plasmox, Fluid Bed.
6.	Timber, Sawdust, Spent Carbon		Eco Logic (T), > BCD > Rotary Kiln, Plasmox, Fluid Bed.
7.	Waters • High concentration		Eco Logic > BCD > Rotary Kiln, Fluid Bed, Plasmox
	• Low concentration		UV > Carbon bed > Bioremediation Bioremediation may be preferred if dioxins not present.

Notes: BCD Base Catalysed Dechlorination
(T) Process incorporates thermal desorption
(UV) UV/ozone/hydrogen peroxide oxidation.

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The Chemistry Department at the University of Waikato has undergone an expansion phase with the addition of Dr Richard Coll, who has a shared appointment with the Cooperative Education team and the Chemistry Department. Richard graduated from Canterbury University, and joins Waikato after working at the University of the West Indies and the University of the South Pacific. In addition, Dr Michael Macalo, a graduate of the University of Auckland, and currently working in Japan, has been appointed as a lecturer, and will commence in July. Associate Professor Lyndsay Main will assume Chairpersonship duties from Professor Brian Nicholson in the near future.

A number of students have recently completed DPhil studies; Warren Tully is doing postdoctoral work with Trigon Packaging Systems Ltd, Mike Tavendale is continuing to work at FRI, and Janine Cooney is doing postdoctoral research at Hort Research, Ruakura. Mark Brown also graduated recently and is allegedly picking watermelons while seeking employment which more closely matches his qualifications. Another recent graduate, Warren Grigsby, returned briefly to enjoy a wedding celebration; he is currently doing postdoctoral research with Professor Phil Power, at UC Davis. Dr Bill Henderson recently received a University of Waikato merit award, and the JE Allan Prize for the best second year chemistry student has been awarded to Rachel Dunn. The Chemistry Department's electrospray mass spectrometer is making those who use it start to wonder how we ever coped without one. Anyone who is interested in exploring the technique for their own types of samples are welcome to contact either Brian Nicholson or Bill Henderson.

Industry/Other News

Congratulations go to Kimai Huirama, a third year chemistry student at the University of Waikato, who has been awarded the first Nga Toa Ngaki Kai scholarship, funded by HortResearch. The Branch Chairperson, Peter Robinson recently spent some time in the USA, and attended the Pittsburgh Conference, as did Branch Committee member Trevor Lock. Martin van Tiel continues to develop his pyrotechnics portfolio, which included manufacture of various whizz-bang effects for the University of Waikato Information Day, held recently. Roger Haslemore has moved from Palmerston North to Hamilton to become Manager of the Non-Routine Section at RJ Hill Laboratories Ltd. RJ Hill Laboratories Ltd have also appointed Nicolaas von Loon from Utrecht in The Netherlands as a Section Leader in their Environmental Section. Nicolaas has seven years of experience in one of the largest environmental laboratories in the Netherlands. RJ Hill Laboratories Ltd has now also purchased a TJA ICP-OES instrument to complement their VG ICP-MS and allow the full range of plant, soil and environmental analyses.

Bill Henderson/Peter Robinson

NZIC PRIZES AND AWARDS

STUDENT TRAVEL AWARDS FOR PACIFICHEM '95

The assessors for the travel awards for PhD student attendance at Pacifichem '95, sponsored by MoRST and NZIC, have now reached their decision. The successful recipients of the $1750 grants are Ms R M Lorimer (University of Auckland) and Mr D C W Reid (Massey University).

The standard of the posters submitted was exceptionally high, and while our sponsorship could not extend beyond two individuals, the assessors were of the clear view that all of the presentations were eminently suitable for presentation at the Congress.

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Professor Bill Denny gave the presidential address earlier in the year, which was well received. The Branch is currently running an analytical chemistry competition for schools, with prizes to be furnished by RJ Hill Laboratories Ltd. Prizes will also be provided at the local Science Fair competition, for the best displays on a chemistry theme. A Branch Ad Hoc Committee has met several times to discuss aspects of the Institute's and Branch's operations.

University News

The Chemistry Department at the University of Waikato has undergone an expansion phase with the addition of Dr Richard Coll, who has a shared appointment with the Cooperative Education team and the Chemistry Department. Richard graduated from Canterbury University, and joins Waikato after working at the University of the West Indies and the University of the South Pacific. In addition, Dr Michael Macalo, a graduate of the University of Auckland, and currently working in Japan, has been appointed as a lecturer, and will commence in July. Associate Professor Lyndsay Main will assume Chairpersonship duties from Professor Brian Nicholson in the near future.

A number of students have recently completed DPhil studies; Warren Tully is doing postdoctoral work with Trigon Packaging Systems Ltd, Mike Tavendale is continuing to work at FRI, and Janine Cooney is doing postdoctoral research at Hort Research, Ruakura. Mark Brown also graduated recently and is allegedly picking watermelons while seeking employment which more closely matches his qualifications. Another recent graduate, Warren Grigsby, returned briefly to enjoy a wedding celebration; he is currently doing postdoctoral research with Professor Phil Power, at UC Davis. Dr Bill Henderson recently received a University of Waikato merit award, and the JE Allan Prize for the best second year chemistry student has been awarded to Rachel Dunn. The Chemistry Department's electrospray mass spectrometer is making those who use it start to wonder how we ever coped without one. Anyone who is interested in exploring the technique for their own types of samples are welcome to contact either Brian Nicholson or Bill Henderson.

Industry/Other News

Congratulations go to Kimai Huirama, a third year chemistry student at the University of Waikato, who has been awarded the first Nga Toa Ngaki Kai scholarship, funded by HortResearch. The Branch Chairperson, Peter Robinson recently spent some time in the USA, and attended the Pittsburgh Conference, as did Branch Committee member Trevor Lock. Martin van Tiel continues to develop his pyrotechnics portfolio, which included manufacture of various whizz-bang effects for the University of Waikato Information Day, held recently. Roger Haslemore has moved from Palmerston North to Hamilton to become Manager of the Non-Routine Section at RJ Hill Laboratories Ltd. RJ Hill Laboratories Ltd have also appointed Nicolaas von Loon from Utrecht in The Netherlands as a Section Leader in their Environmental Section. Nicolaas has seven years of experience in one of the largest environmental laboratories in the Netherlands. RJ Hill Laboratories Ltd has now also purchased a TJA ICP-OES instrument to complement their VG ICP-MS and allow the full range of plant, soil and environmental analyses.

Bill Henderson/Peter Robinson

NZIC PRIZES AND AWARDS

STUDENT TRAVEL AWARDS FOR PACIFICHEM '95

The assessors for the travel awards for PhD student attendance at Pacifichem '95, sponsored by MoRST and NZIC, have now reached their decision. The successful recipients of the $1750 grants are Ms R M Lorimer (University of Auckland) and Mr D C W Reid (Massey University).

The standard of the posters submitted was exceptionally high, and while our sponsorship could not extend beyond two individuals, the assessors were of the clear view that all of the presentations were eminently suitable for presentation at the Congress.

EXCELLENT ICP-MS SYMPOSIUM IN WELLINGTON

The first international ICP-MS gathering to be held in New Zealand was a great success, according to organiser Dr Terry Manning, Corporate Advisor for ESR - the Institute of Environmental Science and Research.

ESR hosted the third Australasian Symposium on applied ICP-Mass Spectometry at Wallaceville, Upper Hutt 3-5 May 1995.

The ICP-MS (Inductively Coupled Plasma - Mass Spectrometer) is a highly advanced analytical instrument capable of detecting trace elements down to concentrations as low as parts per trillion.

ESR's Environmental Chemistry Group Leader, Dr Kevin Fellows, based at Gracefield, Lower Hutt, said it was pleasing to host the Symposium for the first time in New Zealand, as there are only two ICP-MS machines in New Zealand, and 35 in Australia. New Zealand's first ICP-MS, a Perkin Elmer Sciex ELAN 5100, was installed at ESR's Gracefield site in December 1993.

The ICP-MS consists of an inductively coupled argon plasma interfaced to a quadrupole mass spectrometer. Samples, usually in solution, enter the plasma where they are vaporised, atomised and ionised. Part of the ion stream passes into the quadrupole mass spectrometer, where the masses of the ions are analysed to determine the concentrations of the elements.

The machine can analyse up to 150 separate samples in one unattended operation. For each sample it can measure a large number of different elements simultaneously, across a wide range of concentrations. A typical time to analyse one sample is three to four minutes.

This speed, and the range of different elements and samples which can be measured has saved much time and cost.

In New Zealand the ICP-MS has enabled Regional Councils to gain a comprehensive, accurate picture of trace metals and other elements present in ground and stream water. It has also been useful in testing for pollution in fish and shellfish, heavy metal presence in people exposed to metals at work, and many other uses.

The symposium enabled ICP-MS operators, users, and potential users, to meet each other, exchange their ideas and experiences, and hear about new developments. Thirty people attended, half of them from overseas - Australia and the United States.

There was a very fruitful interchange of ideas between the different groups represented, particularly on the use of the flow injection to introduce samples. This topic dominated the second day of the symposium.

Flow injection of samples can boost analysis rates - ESR's machine can analyse 25 samples per hour. Accessories and peripherals are available to allow vapour generation, analyte preconcentration, matrix separation, and dilution, to make the analyte and the sample matrix more suitable for ICP-MS analysis.

Julian Tyson, Professor of Chemistry at the University of Massachusetts, USA, reviewed current flow injection technology, focusing on reducing interferences, and enhancing performance of the ICP-MS.

Colin Eldridge, Managing Director of Australian company Ultra-Trace Ltd, presented his experience in pushing existing equipment to the limit to achieve a faster throughput of samples.

"He was doing gold prospecting solutions at the rate of one in 27 seconds," said Dr Fellows.

This rapid throughput is achieved by placing parts of the system as close together as possible to minimise connecting tubing, and imaginatively using the ICP-MS' programming capabilities. For example, using no or minimal rinsing between samples, but with the software programmed to take into account any carryover from previous samples.

ESR will now be looking at improvements in its own flow injection system, in light of Eldridge's presentation.

"However, we are also using the machine in ways the manufacturer hasn't thought of", said Dr Fellows. An example, is using the flow injection system to speed up flow in the rinse cycle. This can reduce the sample cycle time from four minutes to two minutes in some cases. This increases throughput and decreases running costs.

Another application of flow injection used at ESR and originally a Perkin-Elmer suggestion attracted interest from participants unfamiliar with it. "All samples need an internal standard added to them," said Dr Fellows. "If you do it by hand, it is tedious and subject to error. However we do it on-line with the flow injection equipment". This was demonstrated during laboratory sessions with ESR's ICP-MS equipment. The hands-on sessions enabled symposium participants who were unfamiliar with flow injection, to see the advantages and additional capabilities of the system.

ESR's facilities featured as a particular topic of the conference, as Dr Fellows presented a paper on the 'Clean Rooms' and laboratories used for ultra-trace analysis.

Reliable measurements of elements at levels below parts per billion require careful procedures for collecting, transporting, storing and preparing samples, to ensure there is no contamination. At the sample preparation stage, ESR has a series of six rooms kept to increasing standards of cleanness.

"The main source of heavy metal contamination of low level samples is particulates in the air, so we reduce the number of particulates in the air far below normal levels," said Dr Fellows. This is done through special high efficiency air filters, and carefully controlled pressures in the rooms. Movement of staff between sensitive areas is minimised by having sample pass-through hatches.

The most stringent standards are kept in the Class 100 Metal-Free Clean Room, accessible only to appropriately trained staff. When this room was recently calibrated for cleanness, it was measured at a Class 5 level, according to Dr Fellows.

"It was clear at the symposium that our Clean Rooms are of a higher and more comprehensive standard that those of any of the other laboratories represented," he said. "The precautions we are taking have resulted in measured detection limits well below the United States Environmental Protection Agency's criteria levels for protection of aquatic life".

The criteria levels applicable for New Zealand waters are particularly low, due to the softness of water here.

Data handling at the output end of ICP-MS analysis was another area of beneficial exchange, said Dr Fellows.

Honway Louie from the Australian Governmental Analytical Laboratories (AGAL) presented a paper on Quality Assurance of trace metal analysis, as used at AGAL's New South Wales laboratories. Their QA procedures have been developed to ensure that the right answers are delivered to clients on time, while a clear and traceable record is kept of all data.

"Data handling is very important, as there is so much data. From a big run, we'll get maybe 45 pages of paper, which has to be checked by a skilled analyst and evaluated for quality control," said Dr Fellows. Following the symposium, ESR will be exchanging ideas with ICP-MS laboratories overseas, to share experiences on data handling and automation, as well as sample preparation and analysis techniques.

An e-mail network for ICP-MS devotees has been established as a result of the symposium.

3rd Australasian ICP-MS Symposium participants: From left to right: Dr Kevin Fellows (ESR, Wellington), Marc Norman (obscured) (School of Earth Sciences, MacQuarie University, NSW), Professor Julian Tyson (University of Massachusetts, USA), Mr Gavin Robinson (R J Hill Laboratories, Hamilton), Mr Graeme Chapple (obscured) (Perkin-Elmer Pty Ltd, Australia), Dr Lawrence Pickston (ESR, Wellington), Dr Terry Cooney (R J Hill Laboratories, Hamilton).

The symposium also gave rise to new applications for ICP-MS in New Zealand. Dr Fellows is now looking forward to the first use of ESR's machine for isotope tracing. As a result of the symposium ESR will undertake isotope tracing of cadmium movement in sheep for a new client. Isotope tracing will allow absorption mechanisms and rates of accumulation of cadmium in sheep to be studied. "This is a type of measurement which has not been able to be done in New Zealand before," said Dr Fellows. The advent of ICP-MS in New Zealand now makes this possible. The machine has a resolution of 0.5 to 0.7 atomic mass units (amu), allowing all isotopes to be measured.

Other facilities at the Gracefield Science Centre also attracted symposium participants' interest in a series of ancillary tours.

Contamination-free facilities featured again at Industrial Research Limited (IRL)'s Contained Bioprocessing Plant. This sealed plant houses three fermentors and other equipment used to process biological matter to yield useful products. This includes extracting hyaluronic acid (used for eye operations and dressing wounds) from cows' eyes, and mushroom flavours from mushrooms. The bioprocessing plant is the only publicly available one in Australasia.

IRL also demonstrated the ability of its Nuclear Magnetic Resonance facility to analyse organic compounds in their natural state. This has provided new insights on how the cell walls give apples their crispness.

Trace analysis of organic compounds featured in a visit to ESR's High Resolution Mass Spectrometer, while ESR: Forensic showed their latest developments in DNA typing.

Full proceedings from the symposium are not available, but it is intended to publish some of the papers in the Atomic Spectroscopy journal.

The next Australasian Symposium will be held in two years time at MacQuarie University in Sydney. The Geochemistry Department there specialises in using a laser ablation system for introducing samples. The technique is particularly suitable for mineral analysis.

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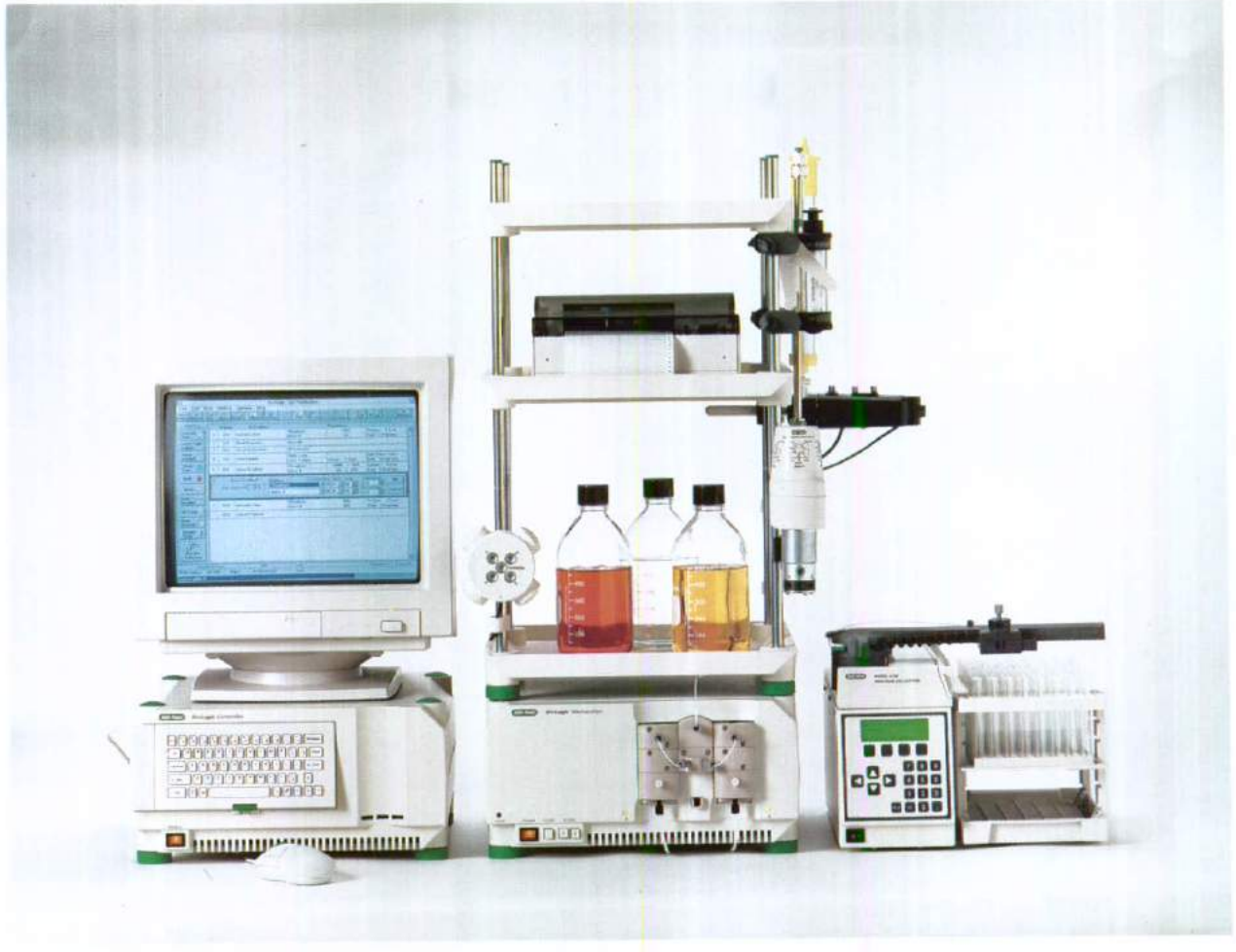

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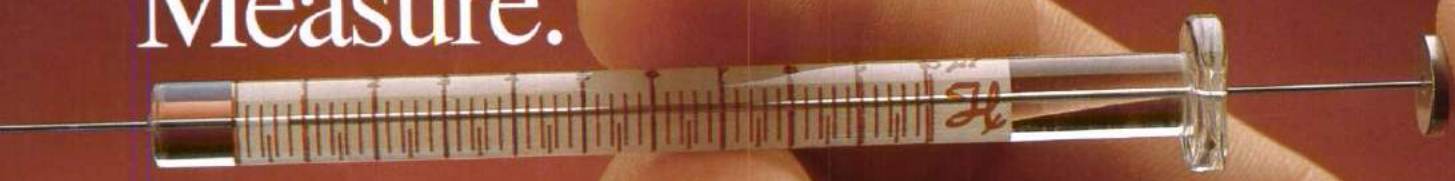

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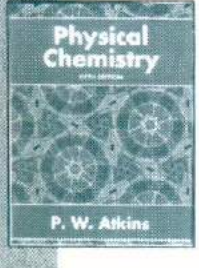

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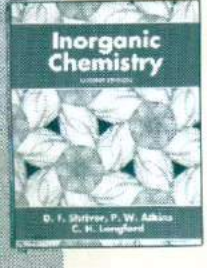

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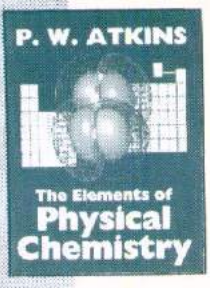

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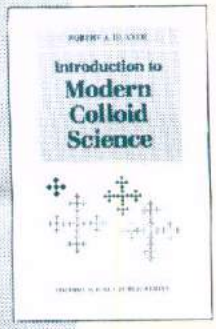

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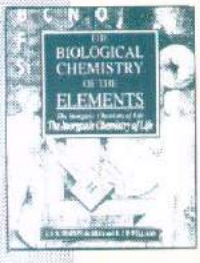

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CHEMICAL BONDING

***Mark J. Winter**, Senior Lecturer, Department of Chemistry, University of Sheffield*

This short text introduces some concepts of chemical bonding in a clear, descriptive and essentially non-mathematical fashion. The book addresses aspects of atomic orbital structure and uses this to develop a discussion of the bonding in diatomic and polyatomic molecules using Lewis dot structures, hybrid orbital, and shape is addressed through the VSEPR method.

Oxford Chemistry Primers
96 pages - UK - March 1994 -
paperback - 0 19 855694 2 - A$12.95 / NZ$17.95
hardback - 0 19 855695 0 - A$47.50 / NZ$64.95

ORGANOMETALLICS 2: *Complexes with Transition Metal-Carbon σ bonds*

***Manfred Bochmann**, Senior Lecturer, School of Chemical Sciences, University of East Anglia, Norwich*

This short text gives and overview of the organometallic chemistry of transition metals. Structural principles and reactions are illustrated with numerous examples. Together with the companion volume Organometallics 1, the text is suitable as the basis for undergraduate courses and revision.

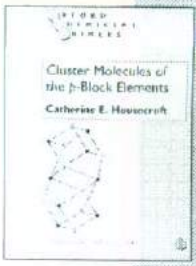
Oxford Chemistry Primers
96 pages - UK - March 1994 -
paperback - 0 19 855813 9 - A$12.95 / NZ$17.95 -
hardback - 0 19 855814 7 - A$47.50 / NZ$64.95

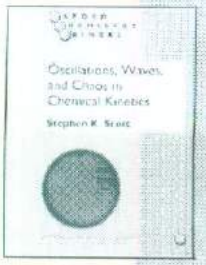
THE NATURE OF CHAOS

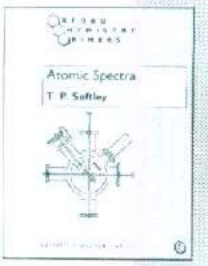
*Edited by **Tom Mullin**, Department of Physics, University of Oxford*

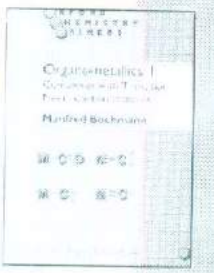
This book captures the excitement of the expert contributors working at the forefront of this new area of science, detailing the latest developments in the different fields; from physics to biology, chemistry, the weather, quantum mechanics, and engineering. It is an edited and updated version of a highly popular lecture series given at Oxford focussing on the applications of ideas from dynamical systems theory. The interdisciplinary nature of the text makes it accessible to the non–specialists but also includes the technical details often lacking in other books on chaos–making this a comprehensive, lively account of the field.

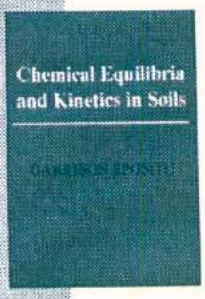
Clarendon Press
338 pages - UK - August 1993 -
paperback - 0 19 853954 1 - A$49.95 / NZ$69.95
hardback - 0 19 853990 8 - A$110.00 / NZ$150.00











CHEMICAL EQUILIBRIA AND KINETICS IN SOILS

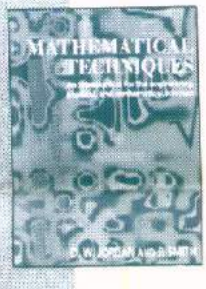
***Garrison Sposito**, Professor Above-Scale, Department of Soil Physical Chemistry, Department of Plant and Soil Biology, University of California, Berkeley*

This book clearly illustrates the limitations of using chemical thermodynamics to describe chemical phenomena in soils-especially with regard to kinetics and molecular mechanisms-and proposes that the quantitative description of soils is not complete without adequate characterization of the rates of the chemical reactions. The author, a renowned authority in the field, focuses on reactions in the soil solution and considers aqueous phase properties. He also cogently draws distinctions between thermodynamic chemical species and kinetic chemical species.

288 pages - USA - October 1994 -
hardback - 0 19 507564 1 - A$110.00 / NZ$150.00

POLYMERS AND NEUTRON SCATTERING

***Julia S. Higgins**, Professor of Polymer Science, Department of Chemical Engineering and Chemical Technology, Imperial College, and **Henri C. Benoit**, Emeritus Professor, Universite Louis Pasteur, Strasbourg*



This is the first book written specifically to introduce the non-expert to the experimental techniques and basic theory necessary to understand the results obtained when using various neutron scattering techniques. Neutron scattering has become widely applied to the study of problems in polymer science and technology and yet there is no other textbook for newcomers to refer to. This is therefore a unique introduction to teh basic theory and techniques making the advantages of neutron scattering, as atool for studying polymer behaviour, much more accessible to the non expert.

Oxford Series on Neutron Scattering in Condensed Matter
Clarendon Press
456 pages - UK - April 1994 -
hardback - 0 19 851003 9 - A$200.00 / NZ$280.00

NMR OF MACROMOLECULES: *A Practical Approach*

*Edited by **Gordon C. K. Roberts**, Professor of Biochemistry and Director, Biological NMR Centre, University of Leicester*

Following the enormous increase in the use of nuclear magnetic resonance to study the conformations and interactions of biological macromolecules, this book provides detailed guidance for the newcomer to this area. It explains how to choose the right experment to obtain the desired information, how to carry out the experiment, and how to analyse the resulting spectra.

For those familiar with chemical applications of NMR but not to biological macromolecules, the book describes the specila requirements of NMR studies of these large molecules.

A truly practical book which no one using these techniques will want to be without.

Practical Approach Series, IRL Press
418 pages - UK - July 1993 -
paperback - 0 19 963224 3 - A$70.00 / NZ$100.00
spiral hardback - 0 19 963225 1 - A$130.00 / NZ$180.00

DICTIONARY OF NAMED PROCESSES IN CHEMICAL TECHNOLOGY

***Alan E. Comyns**, Principal, Alan E. Comyns and Associates, Chester*

The purpose of this new Dictionary is to provide concise descriptions of all the process names in current use, and of the more important historical ones. Many references are provided, documenting the original inventions, definitive reviews, and the current commercial status of the process. Derivations of the names are given where known.

A product index links the names of chemicals and other products with the names of the processes by which they are made.

354 pages - UK - December 1993 -
hardback - 0 19 855385 4 - A$150.00 / NZ$210.00

MATHEMATICAL TECHNIQUES: *An Introduction for the Engineering, Physical, and Mathematical Sciences*

***D. W. Jordan**, Department of Mathematics, University of Keele, and **P. Smith**, Department of Mathematics, University of Keele*

This book offers a course in mathematical methods for students in the first stages of a science or engineering degree. Its particular intention is to cover the range of topics typically required, while providing for students whose mathematical background is minimal.

The topics covered include pre-university material as many science students have never studied mathematics at this level before. The text moves from a very elementary level to more complex material using quite simple examples and a large number of simple fully worked examples. The text is also widely illustrated and includes simple numerical processes which lead to examples and projects for computation. A large number of exercises (with answers) are also included to reinforce understanding.

676 pages - UK - June 1994 -
paperback - 0 19 856267 5 - A$39.95 / NZ$54.95
hardback - 0 19 856268 3 - A$130.00 / NZ$180.00

QUANTUM MECHANICS IN CHEMISTRY

***Jack Simons**, Department of Chemistry, University of Utah, and **Jeff Nichols**, Researcher, Battelle Pacific Northwest Labs*

This graduate level textbook in quantum chemistry offers great flexibility. The introductory material is covered in less detail, allowing the instructor to extend the coverage into areas of greater importance: molecular spectroscopy, chemical dynamics, and a very thorough group of chapters on computational chemistry as applied to electronic structures. It will come in handy for all first-year graduate-level quantum chemistry students.

Topics in Physical Chemistry
656 pages - USA -
April 1995 - hardback - 0 19 508200 1 - A$120.00 / NZ$170.00

MOLECULAR GAS DYNAMICS AND THE DIRECT SIMULATION OF GAS FLOWS

G. A. Bird, *Managing Director, GAB Consulting Pty Ltd.; Emeritus Professor, University of Sydney*

Modern computers are now capable of calculating many complex gas flows from the motion of individual molecules. This book outlines the molecular theory of gas dynamics and describes in detail the direct simulation Monte Carlo (or DSMC) method. The method and its typical applications are illustrated through demonstration programs that are supplied as FORTRAN source codes on a disk enclosed with the book.

This new edition includes calculations that computers were not powerful enough to achieve when the first edition came out in 1976.

Oxford Engineering Science Series
Clarendon Press
476 pages - UK - May 1994 -
hardback - 0 19 856195 4 - A$140.00 / NZ$200.00

CARBON DIOXIDE FIXATION AND REDUCTION IN BIOLOGICAL AND MODEL SYSTEMS

Proceedings of the Royal Swedish Academy of Sciences Nobel Symposium, 1991

Edited by **Carl-Ivar Branden**, *Director of Research, European Synchrotron Radiation Facility, Grenoble, and* **Gunter Schneider**, *Investigator, Department of Molecular Biology, Biomedical Centre, University of Uppsala*

The book contains the proceedings of a Nobel symposium held in Stockholm. This gathered leading experts on different aspects of carbon dioxide chemistry, covering topics as diverse as photosynthetic carbon fixation and electrochemical reduction of carbon dioxide. Given the present public concern about the "greenhouse" effect, this collection of papers by leading authorities is timely.

314 pages - UK - September 1994 -
hardback - 0 19 854782 X - A$260.00 / NZ$360.00

AN ATLAS OF FULLERENES

P. W. Fowler, *Reader in Theoretical Chemistry, Department of Chemistry, University of Exeter, and* **D. E. Manolopoulos**, *Lecturer in Physical Chemistry, Department of Chemistry, University of Nottingham*

This book contains the first comprehensive introduction to the fullerenes, of which the celebrated icosahedral C^{60} molecule (buckminsterfullerene) is the archetype. Rather than covering the detailed properties of specific cages, this atlas emphasises simple results that apply to the fullerene family as a whole. Numerous topics are covered including generation and enumeration, classification, isomerisation, and hypothetical mechanisms for formation and fragmentation. In addition, there is a comprehensive catalogue of fullerene isomers with up to 50 carbon atoms, and isolated-pentagon isomers with up to 100 carbon atoms. A computer program is also provided that can be used to extend this catalogue as necessary.

International Series of Monographs on Chemistry
Clarendon Press
400 pages - UK - January 1995 -
hardback - 0 19 855787 6 - A$200.00 / NZ$280.00

ENVIRONMENTAL CHEMISTRY OF SOILS

Murray B. McBride, *Professor, Department of Soil Chemistry, Cornell University*

This introduction to modern soil chemistry describes chemical processes in soils in terms of established principles of inorganic, organic, and physical chemistry. It aims for a modern conceptual approach rather than empirical description, including the most recently developed explanations for the more controversial topics. The text provides an understanding of the structure of the solid mineral and organic materials from which soils are formed. With the help of diagrams and graphs, it explains such important processes as cation exchange, chemisorption and physical adsorption of organic and inorganic ions and molecules, soil acidification and weathering, oxidation-reduction reactions, and development of soil alkalinity and clay swelling properties.

416 pages - USA - March 1994 -
hardback - 0 19 507011 9 - A$85.00 / NZ$120.00

CHALLENGES IN SYNTHETIC ORGANIC CHEMISTRY

Teruaki Mukaiyama, *Emeritus Professor of Chemistry, University of Tokyo Translation edited by* **J. E. Baldwin**, *Waynflete Professor of Chemistry, University of Oxford.*

Professor Teruaki Mukaiyama is internationally recognized as one of Japan's leading synthetic organic chemists. In this account of his research interests he describes his life's work in organic chemistry, providing a unique insight into his approach to synthetic problems and the development of new synthetic methods.

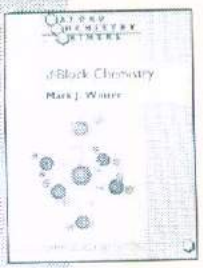
International Series of Monographs on Chemistry
Clarendon Press
234 pages - UK -
May 1994 - paperback - 0 19 855855 4 - A$59.95 / NZ$85.00
July 1990 - hardback - 0 19 855644 6 - A$95.00 / NZ$130.00

ORGANOMETALLICS 1: *Complexes with Transition Metal-Carbon ∂ bonds*

Manfred Bochmann, *Senior Lecturer, School of Chemical Sciences, University of East Anglia, Norwich*

This succinct text outlines the main classes of transition metal organometallic complexes and introduces the reader to the chemistry of compounds with metal-carbon ∂ bonds: metal carbonyls, metal alkyls, and metal alkylidenes and the chemistry of compounds with metal-carbon ∂ bonds: metal carbonyls, metal alkyls, and metal alkylidenes and alkylidnes. The synthetic methods leading to each class of compounds are illustrated with pertinent examples, followed by the discussion of characteristic structures and reactivity patterns.

Oxford Chemistry Primers
96 pages - UK - March 1994 -
paperback - 0 19 855750 7 - A$12.95 / NZ$17.95
hardback - 0 19 855751 5 - A$47.50 / NZ$64.95



D-BLOCK CHEMISTRY

Mark J. Winter, *Senior Lecturer, Department of Chemistry, University of Sheffield*

This concise and accessible Primer covers the d-block metal complexes, an area many students find bewildering due to the large number of structural types these complexes display. Numerous molecular structures are presented, and the clear progression of chemistry employed will lay the foundations for more advanced courses.

Oxford Chemistry Primers
96 pages - UK - December 1994 -
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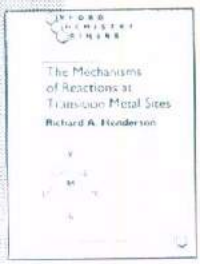

THE MECHANISMS OF REACTIONS AT TRANSITION METAL SITES

Richard A. Henderson, *Principal Scientific Officer, AFRC Institute of Plant Science Research, Nitrogen Fixation Laboratory, University of Sussex*

Understanding the mechanisms of the reactions at transition metal sites is a key component in designing synthetic methods, developing industrial homogeneous catalysts, and investigating metalloenzymes. This completely new text, for an undergraduate audience, provides a broad-based and systematic guide through the fundamentals of transition-metal mechanistic chemistry.

Oxford Chemistry Primers
96 pages - UK - December 1993 -
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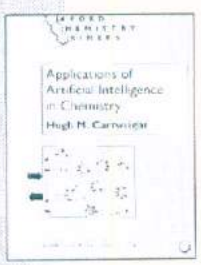

APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN CHEMISTRY

Hugh M. Cartwright, *Laboratory Officer, Physical Chemistry Laboratory, University of Oxford*

The techniques of artificial intelligence are useful for more than just the development of thinking machines; they constitute powerful problem-solving tools in their own right. AI methods can now be used on a routine basis by scientists in academic research as well as the commercial world.

Oxford Chemistry Primers
96 pages - UK - December 1993 -
paperback - 0 19 855736 1 - A$15.95 / NZ$22.95
hardback - 0 19 855737 X - A$47.50 / NZ$64.95

CHEMICAL ASPECTS OF BIOSYNTHESIS

John Mann, *Professor of Organic Chemistry, University of Reading*

This straightforward text provides a concise yet comprehensive introduction to the chemistry involved in the biosynthesis of natural products. It explains the connections between the primary and secondary metabolites, outlines the chemistry mediated by the major enzyme cofactors, and describes the methods for the elucidation of biosynthetic pathways. The different classes of metabolites are then discussed, with an emphasis on the pharmacological and toxicological significance of the various compounds. The ecological significance of a wide variety of natural compounds is also examined.

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hardback - 0 19 855677 2 - A$47.50 / NZ$64.95

MODERN LIQUID PHASE KINETICS

B. G. Cox, *Corporate Research Associate, ZENECA Fine Chemicals Manufacturing Organisation, Manchester*

The measurement and interpretation of the rates of chemical reactions in solution are described in this book, which emphasises their relevance to important chemical, biological and industrial processes. The kinetics of single and complex reaction systems in solution, solvent effects, fast reaction techniques heterogeneous liquid - liquid two-phase systems, phase-transfer catalysis difusion and other topics are introduced and examined

Oxford Chemistry Primers
96 pages - UK - June 1994 -
paperback - 0 19 855744 2 - A$12.95 / NZ$17.95
hardback - 0 19 855745 0 - A$47.50 / NZ$64.95

CLUSTER MOLECULES OF THE P-BLOCK ELEMENTS

Catherine E. Housecroft, *University Lecturer in Inorganic Chemistry, University of Cambridge*

This new addition to the successful Oxford Chemistry Primers series provides a comprehensive survey of the structures, bonding, synthesis, and reactivity of the title molecules and includes clusters found in the elemental state as well as compounds. Terms commonly encountered in cluster chemistry are defined and polyhedral frameworks are described.

Oxford Chemistry Primers
96 pages - UK - April 1994 -
paperback - 0 19 855698 5 - A$12.95 / NZ$17.95
hardback - 0 19 855699 3 - A$47.50 / NZ$64.95

PERIODICITY AND THE P-BLOCK ELEMENTS

Nicholas C. Norman, *University Lecturer, Department of Chemistry, University of Newcastle-upon-Tyne*

This text begins with an introduction to the electronic structures of atoms and shows how these ideas are useful in understanding why the periodic table has the form it does. The periodic aspects of element properties such as ionisation energies and electronegativity are covered, and these concepts are used to understand the diverse physical nature of the p-block elements themselves.

Oxford Chemistry Primers
94 pages - UK - April 1994 -
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hardback - 0 19 855764 7 - A$47.50 / NZ$64.95

ENERGY LEVELS IN ATOMS AND MOLECULES

W. G. Richards, *Reader in Computational Chemistry, Physical Chemistry Laboratory, University of Oxford, and* ***P. R. Scott***, *Deputy Head, Royal Grammar School, Guildford*

The first introductory text of its kind, this inexpensive primer will provide first and second year students in chemistry, physics, and biochemistry with a clear, accessible introduction to the electronic structure and quantised energy levels in atoms and molecules.

Oxford Chemistry Primers
96 pages - UK - December 1994 -
paperback - 0 19 855804 X - A$12.95 / NZ$17.95

ELECTRONIC STRUCTURE OF MATERIALS

***Adrian P. Sutton**, University Lecturer in Materials Science; Fellow, Linacre College, Oxford*

This book describes the modern real-space approach to electronic structures and properties of crystalline and non-crystalline materials in a form readily accessible to undergraduates in materials science, physics, and chemistry.

Clarendon Press
276 pages - UK - September 1993 -
paperback - 0 19 851754 8 - A$49.95 / NZ$69.95
hardback - 0 19 851755 6 - A$130.00 / NZ$180.00

ALGEBRAIC THEORY OF MOLECULES

***F. Iachello**, Department of Physics, Yale University, and **R. D. Levine**, Department of Chemistry, Hebrew University of Jerusalem and UCLA*

This book presents a fresh look at the mathematics of wave functions that provide the theoretical underpinning of molecular spectroscopy. Written by renowned authorities in the field, the book demonstrates the advantages of algebraic theory over the more conventional geometric approach to developing the formal quantum mechanics inherent in molecular spectroscopy. Many examples are provided that compare the algebraic and geometric methods, illustrating the relationship between the algebraic approach and current experiments. The authors develop their presentation from a basic level so as to enable newcomers to enter the field while providing enough details and concrete examples to serve as a reference for the expert. Chemical physicists, physical chemists, and spectroscopists will wnat to read this exciting new approachto molecular spectroscopy.

Topics in Physical Chemistry
272 pages - USA - January 1995 -
hardback - 0 19 508091 2 - A$110.00 / NZ$150.00

CRYSTALLOGRAPHIC COMPUTING 6: *A Window on Modern Crystallography*

*Edited by **H. D. Flack**, Concepteur en Informatique, Laboratoire de Cristallographie, Université de Genève, **L. Párkányi**, Senior Research Fellow, Central Research Institute for Chemistry, Budapest, and **K. Simon**, Head of Research Analytical Laboratories, Chinoin Pharmaceutical and Chemical, Budapest*

This book presents contributions given at the Vesprem School on Crystallographic Computing June 1992, Hungary. Nineteen review articles cover subjects of topical interest in the state of crystallographic software. The application to crystallography of windowing techniques and object-oriented programming is treated for the first time in this series. Recent advances in powder diffraction techniques, both structure and solution, and refinement are discussed. The tricky problem of dealing with disorder in the interpretation of diffraction data is given clear coverage.

International Union of Crystallography Crystallographic Symposia
320 pages - UK - December 1993 -
hardback - 0 19 855788 4 - A$130.00 / NZ$180.00

CHEMICAL OSCILLATIONS AND INSTABILITIES: *Non-linear Chemical Kinetics*

***Peter Gray**, Master, Gonville and Caius College, Cambridge, and **Stephen K. Scott**, Reader in Physical Chemistry, University of Leeds*

Now available in paperback, this book introduces non-linear phenomena in chemical kinetics using simple model schemes. These models involve chemical feedback, such as chain branching, autocatalysis, and self-heating. The emphasis is on physical and pictorial representation, and on identifying those gross features which are essential. The experimental conditions under which such behaviour will occur can be predicted using simple mathematical recipes, and these are also included.

International Series of Monographs on Chemistry
Clarendon Press 470 pages - UK - May 1995 -
paperback - 0 19 855864 3 - A$80.00 / NZ$110.00
hardback - 0 19 855646 2 - A$190.00 / NZ$270.00

A NEW DIMENSION TO QUANTUM CHEMISTRY: *Analytic Derivative Methods in Ab Initio Molecular Electronic Structure Theory*

***Yukio Yamaguchi**, Center for Computational Quantum Chemistry, University of Georgia, **Yoshihiro Osamura**, Department of Chemistry, Keio University, **J. Goddard**, Professor of Chemistry, University of Guelph, and **Henry F. Schaefer III**, both at Center for Computational Quantum Chemistry, University of Georgia*

In modern theoretical chemistry, the importance of the analytic evaluation of energy derivatives from relaible wave-functions can hardly be overestimated. This monograph presents the formulation and implementation of analytical energy derivative methods in *ab initio* quantum chemistry. It includes a systematic presentation of the necessary algebraic formulae for all of the derivations. The coverage is limited to derivative methods for wavefunctions based on the variational principle, namely restricted Hartree-Fock (RHF), configuration interaction (CI) and multi-configuration self-consistent-field (MCSCF) wavefunctions.

International Series of Monographs on Chemistry
496 pages - USA -
March 1994 - hardback - 0 19 507028 3 - A$140.00 / NZ$200.00

REGULATION OF ATMOSPHERIC CO^2 AND O^2 BY PHOTOSYNTHETIC CARBON METABOLISM

*Edited by **N. E. Tolbert**, and **Jack Preiss**, both are Professors of Biochemistry, both at Michigan State University*

This volume is an essential addition to the libraries of researchers interested in the "greenhouse effect" and problems arising from increasing levels of atmospheric carbon dioxide. The work covers both the effects on plants and photosynthetic productivity and, alternatively, the role of plants in regulating the chemical balance of the atmosphere. Contributors evaluate recent research and review many aspects of photosynthetic carbon metabolism explored over the past 40 years.

288 pages - USA - November 1993 -
hardback - 0 19 507932 9 - A$140.00 / NZ$200.00

THE CHEMICAL SYNTHESIS OF PEPTIDES

John Jones, *Lecturer in Organic Chemistry; Official Fellow and Tutor; Dean, Balliol College, Oxford*

The emphasis throughout this book is on the chemical principles behind the more important methods of peptide synthesis. The book begins by covering the basic principles and goes on to look at the strategies and techniques used for synthesizing various types of peptide. Case studies are used to highlight the difficulties involved and the ways in which these can be overcome.

International Series of Monographs on Chemistry
Clarendon Press 240 pages - UK -
April 1994 - paperback - 0 19 855839 2 - A$59.95 / NZ$85.00
August 1991 - hardback - 0 19 855643 8 - A$110.00 / NZ$150.00

DENSITY-FUNCTIONAL THEORY OF ATOMS AND MOLECULES

Robert G. Parr, *William R. Kenan Jr Professor of Theoretical Chemistry, and* ***Yang Weitao***, *Postdoctoral Fellow, both at University of North Carolina at Chapel Hill*

This book is a rigorous, unified account of the fundamental principles of the density-functional theory of the electronic structure of matter and its applications to atoms and molecules. Containing a detailed discussion of the chemical potential and its derivatives, it provides an understanding of the concepts of electronegativity, hardness and softness, and chemical reactivity. Both the Hohenberg-Kohn-Sham and the Levy-Lieb derivations of the basic theorems are presented, and extensive references to the literature are included. Two introductory chapters and several appendices

352 pages - USA -
March 1994 - paperback - 0 19 509276 7 - A$64.95 / NZ$90.00
April 1989 - hardback - 0 19 504279 4 - A$110.00 / NZ$150.00

HIGH RESOLUTION NMR IN THE SOLID STATE: FUNDAMENTALS OF CP/MAS

E. O. Stejskal, *Professor of Chemistry, North Carolina State University, and* ***J. D. Memory***, *Vice-President for Research, University of North Carolina, General Administration; and Professor of Physics*

This text was developed from a course for physical chemistry and chemical physics students using cross-polarization (CP) magic angle spinning (MAS) NMR in their laboratory assignments. The book provides students with the details of the CP/MAS experiment as it is used to obtain rare-spin, high-resolution NMR spectra. The design of the CP/MAS experiments and the interpretation of spectra and relaxation measurements require an understanding of the interplay of several fundamental physical interactions not normally encountered in solution NMR. The student can observe the way interacting spin systems behave in the solid state, and have a quantum mechanically rigorous understanding of solid-state spin phenomena.

208 pages - USA - August 1994 -
hardback - 0 19 507380 0 - A$75.00 / NZ$110.00

BAND THEORY OF SOLIDS: *An Introduction from the Point of View of Symmetry*

Simon L. Altmann, *Emeritus Fellow, Brasenose College, Oxford*

The structure of much of solid-state theory comes directly from group theory, but until now there has been no elementary introduction to the band theory of solids which adopts this approach. This book provides such an introduction, employing only the simplest and most basic of group theoretical ideas, and emphasizing the significance of symmetry in determining many of the essential concepts used in the subject.

Clarendon Press 300 pages - UK - April 1994 -
paperback - 0 19 855866 X - A$59.95 / NZ$85.00

THE ORGANIC CHEMISTRY OF ALIPHATIC NITROGEN COMPOUNDS

B. R. Brown, *formerly Lecturer in Chemistry, University of Oxford; Fellow and Tutor, Oriel College, Oxford*

In recent years there have been considerable advances in organonitrogen chemistry, and many important new reagents and synthetic methods have been developed. This is a comprehensive, definitive modern account of the organic chemistry of aliphatic nitrogen compounds, which will serve as an invaluable reference for all workers in the field.

Each chapter begins with a brief introduction, which is followed by a detailed account of the preparation of the type of compound under consideration. Reactivity and reactions - including mechanistic aspects - are then discussed.

International Series of Monographs on Chemistry
Clarendon Press
794 pages - UK - August 1994 -
hardback - 0 19 855783 3 - A$450.00 / NZ$625.00

PRINCIPLES OF NUCLEAR MAGNETIC RESONANCE MICROSCOPY

Paul T. Callaghan, *Professor of Physics and Biophysics, Faculty of Science, Massey University, Palmerston North*

In NMR imaging the signal is acquired in k-space. A dynamic analogue of k-space imaging is the Pulsed Gradient Spin Echo (PGSE) experiment in which the signal is acquired in q-space.

This book explores principles and common themes underlying these two variants of NMR Microscopy, providing many examples of their use. The methods discussed here are of importance in fundamental biological and physical research, as well as having applications in a wide variety of industries, including those concerned with petrochemicals, polymers, biotechnology, food processing and natural product processing.

Clarendon Press
510 pages - UK -
December 1993 - paperback - 0 19 853997 5 - A$59.95 / NZ$85.00
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