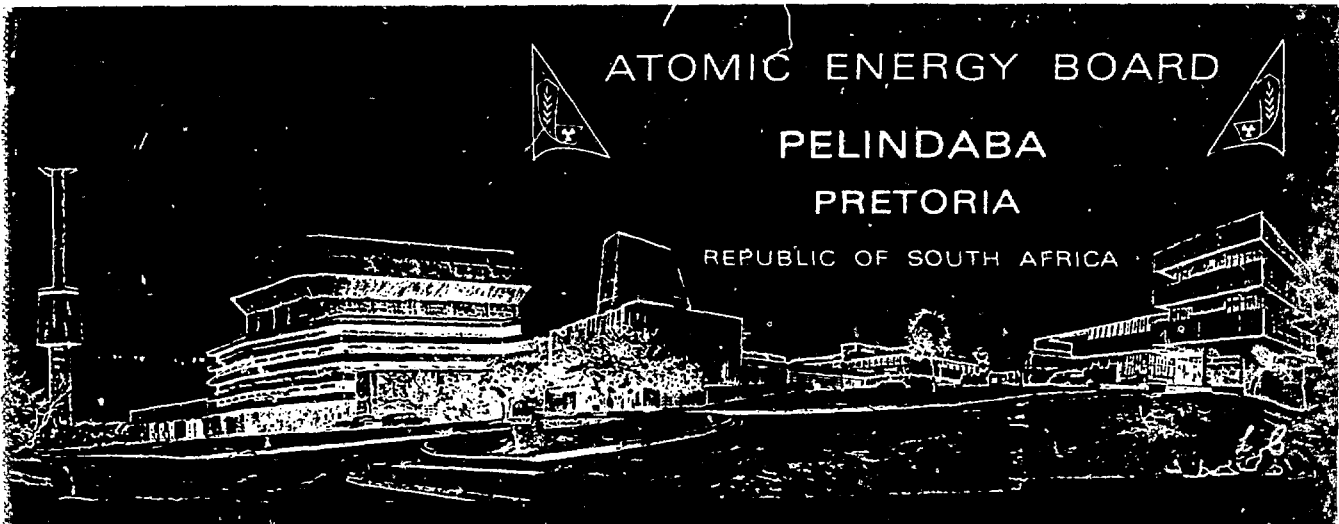


AEB - HIGHLIGHTS

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ATOMIC ENERGY BOARD

PELINDABA

PRETORIA

REPUBLIC OF SOUTH AFRICA

AEB HIGHLIGHTS

AEB HIGHLIGHTS is a half-yearly report reflecting the most important recent achievements of the various Research and Technical Divisions of the Atomic Energy Board. It appears alternately in English and Afrikaans.

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PHYSICAL METALLURGY DIVISION

The computer control of the neutron diffractometer, which is a national facility and the only one of its kind in South Africa, has been brought to a sophisticated level, and diffraction studies can now be undertaken over a range of temperatures.

Hydrogen atoms are not easily detected by X-ray diffraction when they occur next to heavy scatterers (e.g. uranium atoms). This difficulty falls away in neutron diffraction. X-ray and neutron diffraction were used as complementary techniques to detect the hydrogen bonds in a series of new uranium compounds discovered at Pelindaba.

Due to the magnetic moment of the neutron, diffraction of neutrons is a powerful method for investigating the magnetic properties of solid-state materials. A joint research project with the Rand Afrikaans University has been initiated to study magnetic phase transitions in antiferromagnets.

CHEMISTRY DIVISION

PLATINUM-GROUP METALS IN MOLTEN CYANIDE

The construction of a spectroscopic facility to record electronic absorption spectra of platinum-group metals (PGM) has been completed. Valuable information concerning the stereochemistry of various metal ions in cyanide melts has been obtained with this facility. These experimental data, together with infrared and electronic spectra obtained from solidified melts, could also confirm the existence of various new low-oxidation-state cyanide complexes of rhodium, iridium, platinum and palladium, previously postulated in this laboratory. Molten alkali cyanide appears to be a good solvent for spectroscopic and other investigations of unstable low-oxidation-state cyanide complexes of various transition metals, as it is highly reducing and therefore strongly stabilises such species.

These data were also valuable for the formulation of the mechanism by which PGM are extracted from molten cyanide in liquid metals. The degree of reaction with the solvent, as well as the relative activity coefficients of the extracted metal ions in the individual components of the liquid-metal alloy, appear, in most cases, to be the determining factors of the distribution properties observed in extraction systems. These observations now serve as the basis for a continuation of the applied program on the separation of PGM by means of molten-salt/liquid-metal equilibria.

IONIC CONDUCTIVITY PHENOMENA AND MOLTEN SALTS

Two of the effects that influence ionic conductivity in glass and molten salts were identified earlier in this investigation by means of experimental and published data. These two effects, viz. (i) the molar-volume effect and (ii) the conductivity-loss effect, can be used for the explanation of ionic conductivity phenomena in glass and molten salts with great success:

(i) The molar-volume effect presents a very acceptable explanation for the trends of both diffusion and ionic-conductivity isotherms in binary common-anion molten-salt mixtures. These isotherms do not follow the behaviour predicted from the trends of the activity coefficients, due to the difference in molar volume between the two components in the mixture. In the case of binary mixed-alkali silicate glasses, where the change in volume is negligible, as well as in the case of binary molten-salt mixtures of which the molar volumes of the components show little difference, the ionic-mobility isotherms follow the trends of the activity coefficients.

The phenomena observed in the case of the pressure- and temperature-dependent conductivity behaviour of pure molten salts (as is manifested in the volume expansion) can now also be explained satisfactorily by means of the molar-volume effect. The influence of volume expansion, which causes a deviation from true Arrhenius behaviour, decreases with increasing pressure, with the result that, at high pressures, pure molten salts show a conductivity behaviour which is in good agreement with that found for silicate glasses (with their low coefficient of expansion). This similarity further justifies the use of binary mixed-alkali borosilicate glass as a model for molten salts.

(ii) Processed experimental data for binary mixed-alkali borosilicate glass has led to the identification of the conductivity-loss effect. A literature search has indicated that this phenomenon also appears in molten-salt mixtures. This loss effect exists over and above the effects of excess ionic interactions (as manifested by activity coefficients) and the influence of the molar-volume effect.

In binary systems containing cations with different mobilities, the cations may be represented as a circuit with large and small resistances in series and parallel combinations. For extended systems of this type, Kirchoff's laws apply, making it possible to postulate a so-called "bypass" mechanism in order to prevent an accumulation of charge — when fast-moving cations are blocked by slow-moving cations in the conductance path, it must be possible for the fast cations to overtake the slow ones. This process leads to a competition between the different cationic species which, together with the resulting longer conductance path for the fast cations, causes a net loss of conductance in the system. This conductivity-loss effect is composition-dependent.

The positive identification of these two effects will contribute considerably to the explanation of mass-transport phenomena in liquids in general.

PILOT PLANT FOR IRRADIATION OF SUBTROPICAL FRUITS

In January 1977, a pilot plant for the irradiation of subtropical fruits was commissioned at Tzaneen in the north-eastern Transvaal. This facility, financed jointly by the Letaba Cooperative and the Atomic Energy Board, was officially opened by Dr A.J.A. Roux, President of the AEB, in February, and, with its present loading of cobalt-60, is capable of treating 300 kg of fruit per hour. It is intended that this facility be utilised for process and product evaluation on a semi-commercial scale over the next few years, following which a discussion will take place regarding upscaling to a fully commercial operation.

During the past mango season, fruits irradiated in the facility were distributed to widespread national markets, and one relatively large consignment (1 800 cartons) was exported by sea for sale in a European country. Evaluations of small portions of the consignment were made at

Southampton and at ITAL, Wageningen, in the Netherlands, as well as at Tzaneen and Nelspruit on similar fruits held under simulated-shipping conditions. The four evaluations produced results in close agreement, showing that whereas over 90 % of the irradiated fruits were marketable on arrival in Europe, more than 50 % of the non-irradiated 'control' batch were badly diseased, even though a hot-fungicide treatment had been applied. An excellent cash return has been received by the producers from the commercial operation, and this will undoubtedly stimulate increased exports of irradiated mangoes during the next season.

Small consignments of avocados and papayas, irradiated in the Letaba facility, are currently being distributed to distant national markets for evaluation purposes. A petition for provisional clearance of papayas, avocados and dried fruits has been submitted to the Department of Health, approval of which will enable the irradiation facility to be utilised for the treatment of these commodities for sale within the Republic. A second petition, that for unlimited clearance of papayas, strawberries and mangoes, has also been submitted to the health authorities following the recommendation of the joint WHO/FAO/IAEA Expert Committee for unconditional clearance of two of these fruits; chemical evidence to support inclusion of the third has also been submitted.

FIRST UNLIMITED CLEARANCE OF AN IRRADIATED FOODSTUFF IN SOUTH AFRICA

A clearance for the sale of unlimited quantities of irradiated potatoes, treated for the purpose of sprout inhibition, was granted by the Minister of Health in January 1977. The clearance resulted from consideration of a petition, submitted by the Atomic Energy Board, describing the need for and nature of the process, and giving detailed evidence for the wholesomeness of the irradiated product. This is the first 'unconditional' clearance of this kind in South Africa and it is intended that the petition submitted be used as a basis for future petitions for other irradiated foodstuffs.

INCREASE IN THE USE OF LOCALLY PRODUCED MEDICAL RADIOISOTOPES

The total number of consignments of radioisotopes for medical use in the first six months in 1976 increased by 15,8 % for the same period in 1977. This was due mainly to ^{99m}Tc generators; 472 were supplied in the first half of 1977, compared to 345 in the same period in 1976.

Three different kits for labelling with ^{99m}Tc are at present being manufactured by the Isotope Production Centre, viz. pyrophosphate, sulphur colloid and DTPA (di-ethylene triamine penta-acetic acid). These chemical substances are used for bone, liver and kidney investigations respectively. During the first half of 1977, 235 kits were produced, compared to 46 kits in the same period in 1976.

ISOTOPES AND RADIATION DIVISION

TESTING OF CLEAN-AIR FACILITIES

There has been a remarkable increase in the use of clean-air facilities, especially rooms, over recent months. The quality of such facilities is specified in terms 0,5 to 5,0 μm aerosol concentrations as determined with optical counters. In these counters measurements with an optical measuring head are processed electronically; although the electronic adjustment is not difficult, calibration of the optical head can be done nowhere else in South Africa. Several firms requested aid in calibration checks on their instruments and these were performed with standard monodispersed polystyrene aerosols of 1,3 μm diameter at a concentration of two million particles per cubic metre. Out of a total of nine counters tested, only one read correctly within 25 % (or 10 % after calibration). The other instruments were out by factors ranging from 400 % too high down to 20 000 % too low. It seems as if frequent calibrations will be required if the instruments are to give meaningful results.

REACTOR SHIELDING

A scientist from the Division attended the 5th International Conference on Reactor Shielding in Knoxville, Tennessee, USA. Afterwards he stayed six weeks with the Radiation Shielding Information Center (RSIC) at the Oak Ridge National Laboratory to study computer programs used in shielding calculations. To make the visit of use to RSIC as well, specified Benchmark problems for light-water reactors were attempted with the programs, of which some have been completed. The hope was expressed that the joint project would be continued.

LIFE SCIENCES DIVISION

Cancer of the breast is by far the most common malignancy in females in Western countries. Treatment of these patients by surgery, alone or in combination with radiotherapy, has not improved the course of the disease in the past 40 years, whereas chemotherapy by means of a combination of various drugs, each acting on different phases of the cell cycle or on different biochemical targets, contributes greatly to the extended survival of these patients.

However, the two major problems experienced in these cancer patients are

- (i) the early detection of malignant foci which become refractive to the current treatment, and
- (ii) the characterisation and identification of certain highly specific hormone receptors within the cells of the tumour.

Detailed knowledge of the presence, concentration and interrelationship of these molecules enables the institution of a highly specific treatment regime, with appreciably prolonged disease-free survival of the patient.

In an endeavour to alleviate the above two serious problems, this Division, in collaboration with the Department of Oncology and Chemotherapy of the H.F. Verwoerd Hospital, commenced a study of patients with cancer of the breast.

By means of an extremely sophisticated radioimmunoassay, 468 blood samples from 266 patients were evaluated for the presence of a tumour-specific glycoprotein. When detected in the patients, plasma follow-up studies were undertaken, as a rise in initial values indicates re-occurrence or dissemination of the tumour between six months and two years prior to clinical manifestation. In this manner 31 sub-clinical deteriorating patients under treatment were identified, and six showed dramatic improvement under the specific treatment schedule. These findings are of immense scientific value as all the patients studied are included in one of five International Collaborative Breast Cancer Research Groups. This latter program is one of the most extensive in cancer research in the world and is conducted under the auspices of the National Institute of Health in the USA.

In addition to the above studies, and as a further research extension, the Division also obtains tumour material, at the time of radical surgery for breast cancer, for the determination of the presence and concentration of specific intracytoplasmic and intranuclear receptor proteins for three steroid hormones.

These investigations, in conjunction with the aforementioned blood-plasma determinations on breast cancer patients, are unique in Africa and on a par with, if not already more advanced than, studies being conducted in Europe and the Americas.