AU9917981

DIVERSE APPLICATIONS OF RADIATION CHEMISTRY

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Radiation Chemistry began as early radiotherapists needed a reliable and appropriate dosimeter. The Iron Sulphate dosimeter, using ferrous iron in sulphuric acid and oxidation by irradiation, was a nasty brew of chemicals but it was sensitive, reliable and conveniently had the same density as human tissue. The full mechanism for its action took almost thirty more years to elucidate. In this time the chemical-physics of the interaction of X rays, γ-rays, electrons, protons, α–particles with water was quantitatively worked out. The fundamental species generated in water by radiation can now be utilised with qualitative and quantitative control. Oxidising or reducing conditions can be generated as well as a library of free radicals useable in chemical synthesis.
The ability to generate solvated electrons in water enables inorganic coordination chemistry to probe electron transfer processes in transition metal complexes. These molecules are considered as candidates for solar energy conversion systems as well as controlled drug release agents.. Radiation chemistry can quantitatively produce and study the redox forms of these compounds whereas photolysis cannot.
Water irradiation chemistry studies were driven by the need to understand the fundamental processes in radiotherapy ; to control the corrosion problems in the cooling/ heat exchange systems of nuclear reactors and to find stable solvents and reagents for use in spent fuel element processing.
Common organic liquids, hydrocarbons, alcohols, and aromatics were examined and a new area of free radical and electronic excited state chemistry opened up. The use of scintillation counting techniques in radionuclide assay was significantly enhanced by the radiation chemical studies of the luminescence from a new range of organic scintillators. Chain reactions induced in irradiated unsaturated hydrocarbons enabled profitable commercial production of petroleum additives.

The electrical and mechanical stability of materials in high radiation fields stimulated the attention of radiation chemists to the study of defects in solids. The coupled use of radiation and ESR enabled the identity of defect structures to be probed. This research led to the development of the sensitive **T**hermo**l**uminescent **D**osimeters, TLD's and a technique for dating of archaeological pottery artefacts. More recently the ESR detection of free radicals has been used to determine the extent of irradiation in food preservation. The electrical breakdown of insulators has also been a cross discipline study by radiation chemists and solid state physicists. Recently a workshop in the USA examined the use of ultra high purity sapphire (Al_2O_3) as the electrical insulator and first wall material in a high temperature fusion reactor; measurement of the radiation induced conductivity by pulse radiolysis was a significant factor in this decision.
The gas cooled reactors stimulated research into the stability of irradiated gases. Initially carbon dioxide was the prime target but subsequently the field broadened. It has been realised that ionising radiation methods, especially using relatively low energy electrons $\sim$ 1 MeV, were powerful means to produce gas phase ions, free radicals, excited states and low energy secondary electrons; in other words, a PLASMA. The pulsed irradiation technique enabled direct observation of the formation and reaction of species important in atmospheric chemistry. Oxygen atoms forming ozone could be monitored as could the reaction of atmospherically important excited states such as those of nitrogen, oxygen and OH radicals. Flue gas clean up by low energy electron beam treatment is under development in europe. Conductivity methods adapted to nanosecond time resolution can directly measure electron cooling, capture and recombination processes in gases-all crucial processes in describing and modelling electrical discharge phenomena such as is found in lighting, welding, gas lasers, atmospheric electrical storms, surface etching etc.
Radiation chemistry in the area of medicine is very active with fundamental studies of the mechanism of DNA strand breakage and the development of radiation sensitisers and protectors for therapeutic purposes.
The major area of polymer radiation chemistry is one which australia commands great international respect. It will be the topic of a later presentation in this conference.