ABSTRACT

With a view to develop technology for treatment of gaseous radio nuclides, which are released through air-route during operation of nuclear power plants and reprocessing plants, a systematic review of the treatment schemes employed for various operating nuclear facilities both in global and Indian context had been summarised.

In the present study, treatment of iodine, tritium and moisture was taken up and studied in detail. Indigenous material like silver exchanged zeolites based on 13X and mordenite type were developed and tested for their use in off-gas cleaning of reprocessing plant. For cover gas cleaning of PHWR (MAPS) and Research Reactor (Dhruva), a Pd/Al₂O₃ catalyst for combination of D₂ and O₂ was developed and evaluated. Studies on removal of moisture so formed were systematically carried out using dual bed of molecular sieves 4A. The data on evaluation generated in the laboratory was useful in design of heavy water recovery systems and tritiated water vapour recovery systems.

The studies on development of silver sorbent were taken up by exchanging of silver ion with sodium ion present in the molecular sieves 13X and AR1 using a packed column. Keeping the packing characteristics constant throughout the experimental conditions; the flow rate of silver nitrate was passed at 1.5 and 2 ml per min and the silver nitrate concentration used was 20g/l and 40g/l. The outlet from the column was continuously titrated using volumetric titration of silver nitrate with sodium chloride and from the break through curve optimisation of parameters was ascertained on the basis of the maximum exchange characteristics. It was observed that lower flow rate and lower concentration had given better utilisation and thus better exchange characteristics.

Silver sorbents developed in the laboratory were evaluated for the purpose of removal of methyl iodide vapour from air at varying range of concentration of methyl
iodide, residence time and moisture content and temperature. Ageing aspects were also studied. Effect of NOx on the removal of methyl iodide was studied. Extent of utilisation of silver for removal of methyl iodide was studied. Break through capacity and removal efficiency were obtained at various intervals during the evaluation stage and were plotted. For all these studies, a removal efficiency higher than 95% at a residence time of 0.2 sec. was achieved. For a residence time of 1.2 seconds a DF of 100 could be obtained when the temperature of the bed was kept at 170 degree C.

Studies were carried out for development of a suitable Pd/Al₂O₃ catalyst for combining H₂ and O₂. Γ alumina pellets of spherical shape, of diameter 3-5 mm with surface area of 150m²/g, 40% porosity, and packing density 1g/cc were used as suitable support material. The choice of the support material was based on better impregnation and packing characteristics. The parameters for impregnation were optimised on the basis of best reaction efficiency under similar conditions. After selection of the suitable parameters for impregnation, pellets were impregnated by contacting them in 2-g/lit palladium chloride solution for 4 hrs. The ratio of the solution to the pellets was kept at 2:1. This resulted in uniform impregnation of the pellets. These impregnated pellets were removed from the solution, transferred to double the volume of distilled water and heated till boiling. Then formic acid in the ratio of 5cc for 500 cc of pellets was added and the reaction of reduction was found to be instantaneous. The palladium /alumina pellets were removed, dried and heated to 110°C for 2 hours and the catalyst was tested for its evaluation under varying parameters like space velocity, hydrogen concentration and temperature.
An experimental set up had provision for the control and measurement of flow rate of hydrogen, nitrogen and air; a mixer to get uniform mixture of gases and a bed of catalyst made out of glass of 33 mm diameter and glass joints at both the sides for introduction and exit of the gas mixture. The temperature was measured at the centre of the bed and a gas chromatograph with thermal conductivity detector was employed to determine hydrogen concentration before and after the catalyst bed. Nitrogen was used as a carrier gas. Sensitivity for hydrogen was found to be 50 ppm.

These studies had indicated the use of this catalyst at room temperature for efficient combination of hydrogen at hydrogen concentration of 2.0% and above. For hydrogen concentration 2.0% and below it was suggested to use about 110°C to achieve 100% conversion efficiency when the space velocity is 30,000 hr⁻¹ or below. The indigenously prepared catalyst was compared with the catalyst of foreign origin used in cover gas cleaning system and found to give better performance. The catalyst was found to be useful in its application for gas chromatographic analysis where argon and oxygen were analysed by a combination of two separating columns. One column (MS 5A) gave combined peak for argon and oxygen and the combination column of MS 5A with catalyst eliminated oxygen with hydrogen carrier and thus gave only argon peak. The difference was due to oxygen and it was determined.

Different types of locally available molecular sieves of synthetic origin were evaluated for their moisture removal efficiency and break through capacity at a specified inlet moisture concentration and face velocity. The efficiency of the moisture removal was calculated and by comparing the outlet moisture with the in-let moisture and it was observed that both molecular sieves 5A and 4A were equivalent in their moisture removal
but molecular sieves 5A was slightly better as far as the moisture removal efficiency was concerned but regeneration and attrition characteristics were found to be better for molecular sieves 4A and hence further studies on finding the break-through capacity and regeneration aspects were carried out on molecular sieves 4A.

Regeneration aspects for molecular sieves 4A were studied to find the amount of hot air required to regenerate the saturated bed so as to provide the desired removal efficiency for the next cycle after regeneration. It was possible to predict the required time for regeneration using the data generated. Regeneration aspects of molecular sieves 4A by heating under vacuum by repeated cycling was studied to find its useful life and the studies revealed that the molecular sieves 4A of local origin gave useful life for 300 cycles.