Fluidized Bed Denitration of Uranyl Nitrate

In India the oxides of uranium are produced after treating the uranyl nitrate pure solution (UNPS) with ammonia (NH_3) and subsequently calcining the resultant ammonium diuranate (ADU). This process involves several steps such as neutralization of the UNPS with NH_3, precipitation, filtration, drying, and calcination of ADU. On the other hand an economical and efficient way is to decompose the uranyl nitrate solution thermally and obtain the oxides of uranium in a single step. Direct thermal denitration offers savings in chemical costs, since it avoids the use of NH_3 and permits the recovery of nitric acid. The direct thermal denitration of uranyl nitrate solution has been demonstrated in a bench scale fluidized bed reactor at Chemical Engineering Laboratory – III of Chemical Engineering Division. The excellent heat transfer characteristics and mechanical simplicity of fluidized beds were adequate inspiration for the development of a denitration process based on this technology.

Direct thermal denitration of uranyl nitrate solution has been demonstrated in a 150 NB bench scale fluidized bed reactor. In the series of experiments, the operating parameters are optimized for continuous, agglomeration free, and smooth operation. The reactor was operated using U_3O_8 (250 – 500 micron) as starting bed material and with a feed rate of 5 – 6 LPH (125 – 300 g U/ l). The bed temperature was set at 380^0C. Total 1000 l solution was processed and 150 kg coarse UO_3 particles were collected. Online regeneration of filter candles using blow back air and online solid withdrawal from the reactor to the product collection vessel were successfully tested during continuous operation of the reactor.

The product (orange oxide, UO_3) withdrawn from the reactor was used for powder characterization and further conversion. The moisture, U and residual NO_3^- content of the product were 0.07%, 82.38% and 2182 µg/ g respectively. The fine UO_3 powder (8.34 µm) obtained from filter housing during operation was reduced with ammonia in a static bed reduction set up at 750^oC to produce UO_2 (O/ U ~ 2.06 – 2.09) at Uranium Extraction Division. The UO_2 powder was taken for both pellet production and hydro-fluorination reaction. The green pellet (10 mm dia.) density was obtained as 6.28 g/ cm^3 at 455 MPa compaction pressure. These pellets were sent to AFFF, Tarapur for sintering. The sintered pellet density was in the order of 9.05 g/ cm^3 (~90% of theoretical density). In the other route UO_2 was then hydro-fluorinated at 450^oC in a static bed set up with anhydrous HF and metal grade UF_4 (Moisture: 0.11%; Free

Acidity: 0.45%; UO_2F_2: 1.96%; AOI: 0.7%) was produced from UO_2 and also U metal produced from the UF_4.

It was proposed to setup similar direct denitration denitration demonstration facility at PREFRE-2, Tarapur. Safety Clearance for this facility has been obtained from ULSC – NRB (T). Equipment installation and piping work has been completed.

Bench Scale Denitration Facility at CEL – 3, ChED

UO_3 produced in direct denitration process

UF_4 produced from fine UO_3 powder