Recovery of the Uranium from phosphate rock by dual process: Phosphoric acid Purification and Uranium Extraction

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The rapid increase in uranium oxide (U_3O_8) prices over the last few years, and the changing fundamentals in the world's uranium supply/demand balance have re-kindled the interest in extraction of uranium from phosphoric acid.

The Groupe Chimique Tunisien is therefore considering a technology solution for extracting uranium from phosphate rock during the purification of the phosphoric acid process.

However, this work realized in the research GCT laboratories, purpose to combine a PPA (Purification of Phosphoric Acid) with a recovery of Uranium from Wet Phosphoric Acid (WPA) in one complex and to have one pre-treatment plant for both processes.

1. Overview

The analysis of the industrial phosphoric acid shows the existence of impurities from the phosphate rock mainly. This gives the physicochemical characteristics (viscosity , high mineral contents elements : Mg , Cd , Fe , Al and organics matter) of the acid detrimental for targeted applications.

The purification of this acid can significantly reduce the levels of these impurities.

This reduction is ensured by the GCT: Groupe Chimique Tunisien through a pilot operating with the liquid-liquid extraction processes and implementing by selective solvent extraction of phosphoric acid H_3PO_4.

The key process equipment is an extraction column controlled by a pulse generator of adjustable pulse frequency and amplitude so as to create the column in an intimate contact between the aqueous phase: phosphoric acid, and the organic solvent, which promotes the mass transfer of the phosphoric acid from the aqueous phase through the organic phase.

However, an organic phase is recovered called: rich extract and solvent containing phosphoric acid as a solute, and an aqueous phase called: Raffinate rich in impurities.

Uranium element exists in the raffinate and is proposed to extract.

An assessment of global and specific material balance for uranium, show that all of the uranium originally existing in the aqueous phase in the phosphoric acid, was completely trapped raffinate phase which also justifies the selectivity of the solvent chosen to

extract phosphoric acid . This solvent has captured phosphoric acid leaving the impurities including uranium in the raffinate phase.
With the same P_2O_5 concentration, the comparison between phosphoric acid and extraction raffinate, shows that the uranium concentration was multiplied by a factor of three.
This also justifies the extraction of this element not from phosphoric where its concentration is relatively low, but from the extraction raffinate acid.

2. Experimental Conduct

This experimental work was carried out in three steps:

- First step: Conducts experiments following an experimental plane of order 2 with 24 experiences with the objective to determine the optimal settings ensuring both maximum performance of dissolution of P_2O_5 phosphate and total passage of uranium phosphate in the acid phase ;

- Second step: Purification of the phosphoric acid from the first step and recovery of the extraction raffinate. This step is performed at the driver level by contacting the acid with the solvent extraction 1, according to known parameters and an appropriate protocol. The purpose of this step is twofold: purify phosphoric acid and recovering the extraction raffinate ;

- Step Three: The rich Uranium extraction raffinate is treated in a mixer settler with solvent 2: DEPA / TOPO respecting the known PRAYON process steps. The objective of this step is to get the yellow cake illustrating the recovery of Uranium element.

3. Chemical analysis of the raw materials involved

3.1 Industrial Phosphoric Acid

Table 1: Industrial Chemical Phosphoric Acid

Element	Unit	Concentration
P_2O_5	(%)	26
CaO	(%)	0,5
MgO	(%)	0,5
SiO_2	(%)	0,2
H_2SO_4	(%)	0,8
Fe_2O_3	(%)	0,2
Al_2O_3	(%)	0,3
F	(%)	0,7
Organics Matter	(%)	0,035
Uranium	(ppm)	30

3. 2- Solvent 1 for the extraction of H_3PO_4 from industrial phosphoric acid

- Purity: 98.5%
- Water content: 1%
- Impurities: 0.5%

3. 3- Solvent 2 for the extraction of uranium from the raffinate from the purification of industrial phosphoric acid

- Purity: 99.5%
- Water content: 0.2%
- Impurities: 0.3%

3. 4- Raffinate from the purification of industrial phosphoric acid

Table 2: Chemical Analysis from Extraction raffinate

Element	Unit	Concentration
P_2O_5	(%)	42
U	(ppm)	120
SO_4	(%)	0,4
Cd	(ppm)	15
F	(%)	0,22
Organics Matters	(ppm)	400

- Operating Parameters

The main factors those are dependent on the extraction:

- Sulphates Concentration SO_4^{2-} in the phosphoric acid;
- H_3PO_4 concentration;
- Fe^{3+} concentration in the phosphoric acid;
- The DEHPA concentration in the mixture **(TOPO + DEHPA + Kérozène)**

These parameters were determined by the experimental design method in an orthogonal plane of order 2. However, the total number of experiments is 24 experiments.

- Study Results

The results of the study showed that:

- Ratio SO_4^{2-}/P_2O_5 : $6.10^{-2} - 15.10^{-2}$
- Temperature: 78 – 82°C
- Concentration P_2O_5 : 20-25%P_2O_5
- % Solid in the reaction vessel : 30- 35%
- Fe^{3+}/P_2O_5 ratio: $0{,}95.10^{-2} - 10^{-2}$
- DEHPA Concentration in the mixture: 0,3 M
- P_2O_5 Efficiency: 93-95%

4. Conclusion

The application of these parameters resulted in the following end products:

- A pure phosphoric acid according to the physical and chemical specifications published in the Official Journal of the EEC
- A yellow cake mass 0.6 g.

With the price of the industrial phosphoric acid, purified acid, and yellow cake, an economic calculation amply justifies this operation.