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LEACHING OF URANIUM AND VANADIUM FROM KOREAN DOMESTIC ORE

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Abstract

Countries like Korea having very limited uranium resources and founded deposits having low grade metal values. Uranium is the main source to generate the nuclear power as cheap and more quantity of the electricity will generate. For this reasons the upcoming researchers in developed/developing countries are establishing more research and development on extraction and separation technologies for uranium. The present scientific study focused on leaching process of Korean domestic ore. The following experiments are carryout for optimization of the leaching process. Acid influence on leaching process was tested and noted that 2.0 M sulfuric acid concentration is the optimized conditions for present study. The time influence on leaching process was observed and its optimized 2 h for complete leaching process. The temperature influence tested and optimized the 80^0C for complete leaching process and pulp density is 50% (wt %).

Introduction

Uranium need going very fast in developed countries and Korea having low grade uranium ores associated with valuable metal vanadium and other impurities like iron, aluminium, silicon predominantly. The present study focused on both metals such as uranium and vanadium recovery and separation for country needs. For the recovering process leaching is the first step in hydrometallurgical methodology. The first stage targeted both metals leaching in next stage separate the each other.

Before began the any process the literature review will give the past reported information as well as new ideas for present study. The literature review noted the following reported methodologies on uranium leaching process. Uranium content in phosphate rock was leached with alkaline solutions like ammonium carbonate and bicarbonate and produced uranyl carbonate by Guzman el at [1]. The uranium leaching process established by using $Fe_2(SO_4)_3$ with H_2SO_4 as one set then sulfuric acid having low nitric acid combination as another set by Shakir et al [2], further the leach liquor proceeded by liquid-gel extraction. Buck and coworkers from Argonne National Laboratory developed a procedure to remove the uranium(IV) by carbonate leaching process in presence of oxygen [3]. Uranium in 4^{th} oxidation stage leached by above said process was follows:

$$UO_2 + 1/2\ O_2 + 3CO_3^{2-} = [UO_2(CO_3)_3]^{4-} + 2OH^- \quad \text{.....(1)}$$

The new leaching system hydrogen peroxide and sodium sulfate with sulfuric acid was applied for uranium. Advantage of this methodology is to reduce the sulfuric acid concentration 700 to 400 g acid kg^{-1} [4]. Uranium content in various oxidation states such as four and six was selectively leached by HCl [5]. Nanomaterials used for in situ chemical leaching of uranium ore and developed mechanisms [6]. From the various waste sources uranium was leached long term by Patra et al [7]. The present leaching procedure developed for both metal ions uranium and vanadium leached and further recovery and each other separation procedures going to establish by using extraction process.

Materials and Methods

Apparatus and reagents

Uranium and vanadium metals analysis was carryout using inductively coupled plasma optimal emission spectrometer (ICP-OES) Perkin Elmer Model Optima 2000 Dr. All reagents used were analytical reagent grade. Korean domestic ore sample present as Fig. 1.

Figure 1. Korean domestic ore sample

The chemical composition of the Korean domestic ore sample was presented in Table I.

Table I Chemical composition of Korean domestic ore sample

Component	Content (%)	Component	Content (%)
U_3O_8	0.058	P_2O_5	0.25
V_2O_5	0.16	ZnO	0.03
SiO_2	55.1	NiO	0.08
Al_2O_3	7.45	S	0.19
Fe_2O_3	3.47	Fixed carbon	26.9
CaO	0.35	H_2O	~5.1
MgO	0.85		

Leaching Procedure

The experimental set up for the leaching process made by pyrex material to face the sudden temperature changes in sulfuric acid leaching process. During a leaching process density of the water evaporation will occurred to prevent this reflux condenser was set to on upper portion (Fig. 2). Loaded thermocouple will measures the temperature of the reaction water and set the temperature ±2^{o}C inside and outside of the room. After reaching the optimum temperature condition the uranium ore sample was added to sulfuric acid solution by systematically. Mechanical agitator used for proper mixing the sample with acid solution. The agitation speed keep 500 rpm for all experiments in the present study. Analysis of the metals s was recorded by ICP-OES and leach rate was calculated. The general agreement between the percent leaching obtained was within ± 2%. Collected

Figure 2. Experimental set up of the leaching process

Results and Discussions

Effect of time

The first experiment tested the time influence on leaching process. The obtained results presented as Fig. 3. The preliminary studies on time optimized 2 h time requires for both metals leaching process and all other experiments keep leaching process up to 2 h.

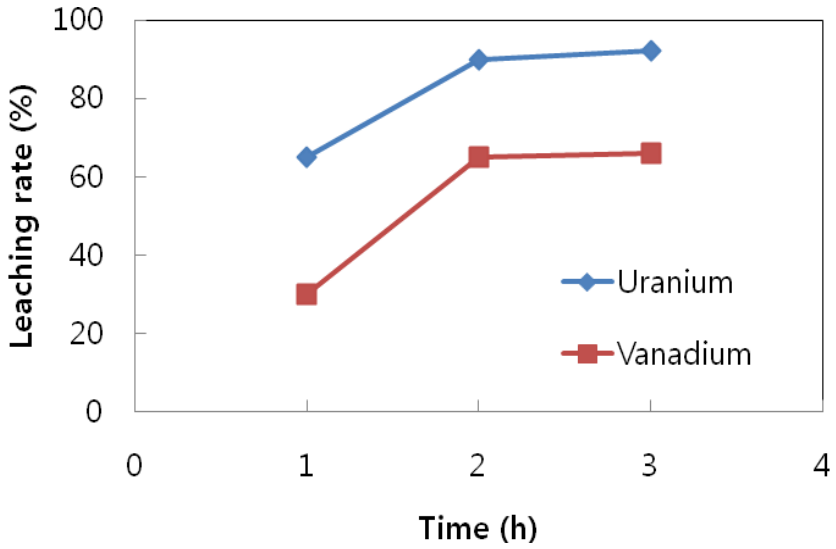

Figure 3. Effect of time on Korean domestic ore leaching process

Effect of particle size

The particle size of the Korean domestic ore sample was tested and obtained results are presented as Fig. 4. The results clearly demonstrate that, -48 mesh size is ideal for both metals.

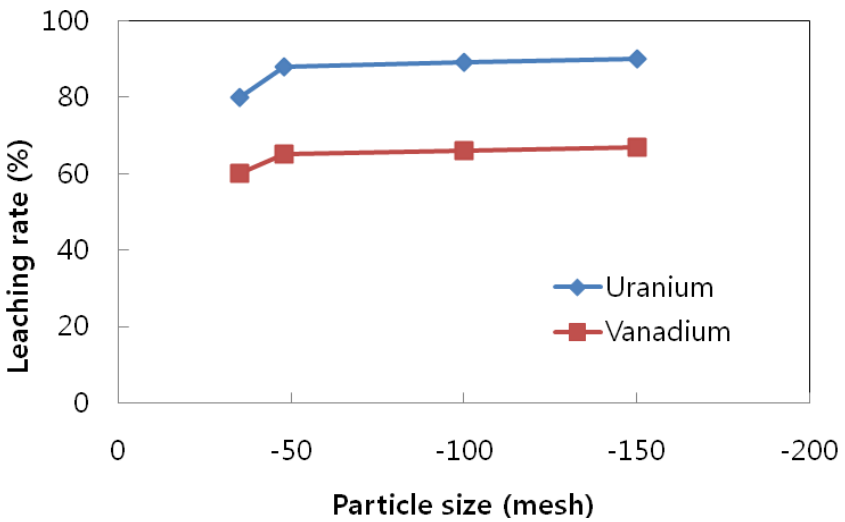

Figure 4. Particle size effect on Korean domestic ore leaching process

Effect of acid concentration

The effect of sulfuric acid concentration on uranium and vanadium leaching process from uranium ore was carried out in between 1.0 to 7.0 M of acid concentration. The metal leaching rate increased with increases acid concentration and sharp increase in leaching rate with variation from 1.0 to 2.0 M of sulfuric acid concentration. Very slow increase in leaching rate with variation from 2.0 to 6.0 M sulfuric acid. The present study concludes that, 2.0 M acidity is good to precede further experiments. The results were presented in Figure 5.

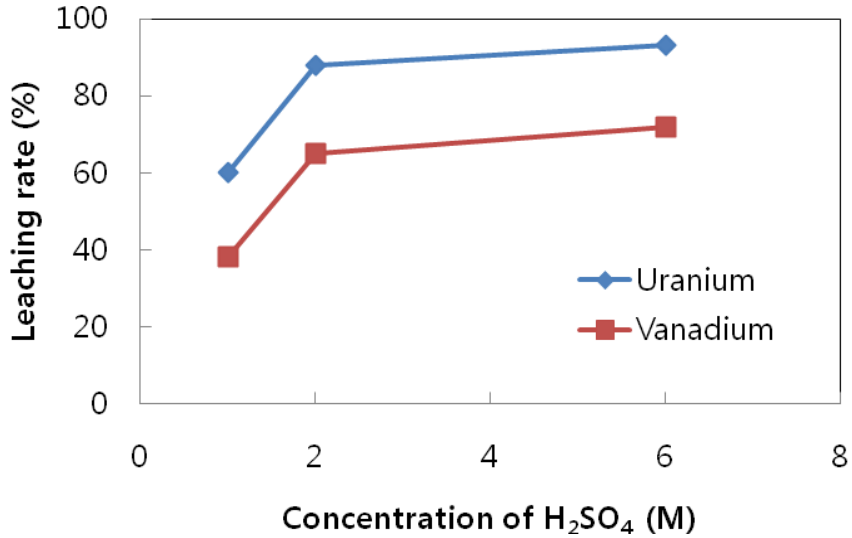

Figure 5. Effect of sulfuric acid concentration on uranium vanadium leaching process from Korean domestic ore

Effect of temperature

Temperature influence play key role in leaching process and the present study carry out temperature effect on uranium ore processing. The temperature varied 60 to 80°C and the results are presented as Fig. 6. The experimental results given final conclusions for uranium highest leaching rate observed at 80°C where as for vanadium 60°C temperature was suitable. Further experiments temperature fixed as 80°C to leach both metals.

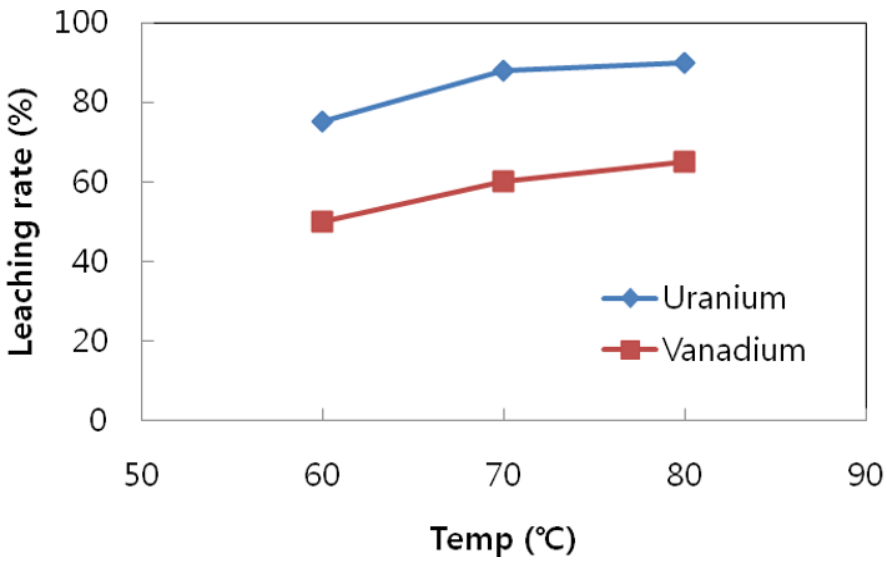

Figure. 6 Effect of temperature on uranium vanadium leaching process from Korean domestic ore

Effect of pulp density

Productivity of the leaching process was interlinked with density. For this reason it's necessary to test the density effect on the leaching operations and optimize the process. Very little variations in leaching rate was observed at various pulp densities (PD) from 20 to 60 wt. %, for further experiments PD was fixed as ~50 wt. % (Fig. 7) .

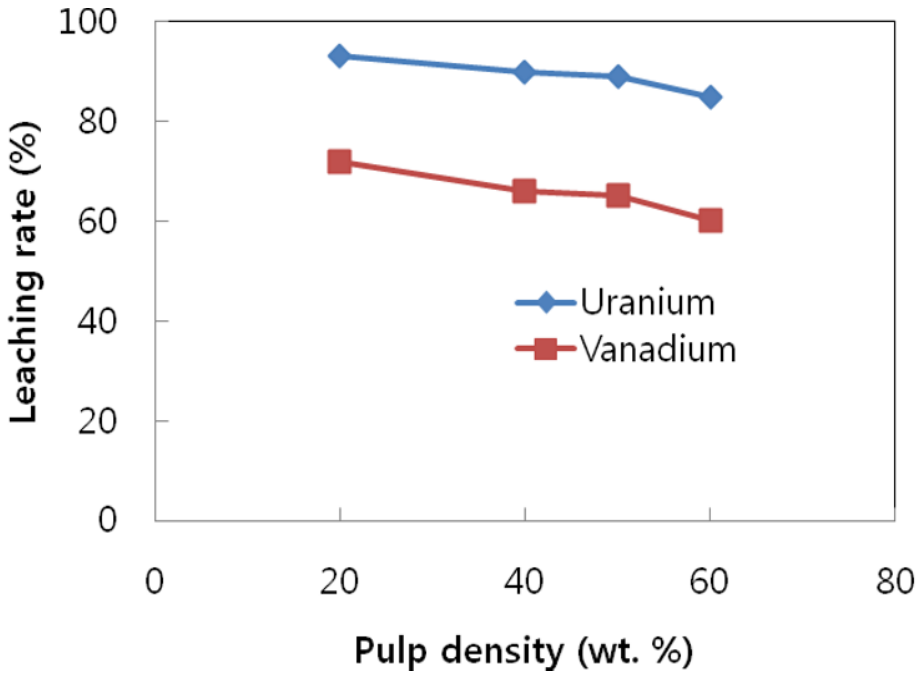

Figure 7. Effect of pulp density on uranium vanadium leaching process from Korean domestic ore.

Conclusions

The following conclusions drawn from the present investigations on leaching process for uranium and vanadium metals from Korean domestic ore:

1. The leaching process experimental conditions optimized for uranium and vanadium metals from Korean domestic ore and developed the basic experimental procedures such as time, particle size, acid influence, temperature effect and pulp density behavior
2. The basic time effect experiment concludes that 2 h time is sufficient for uranium and vanadium leaching process.
3. Even the moderate sulfuric acid concentration i.e 2 M acid leached ~ 90 to 94 % of uranium leached whereas same experimental condition ~65 to 72% of vanadium was leached from ore sample
4. The target metals uranium and vanadium was leached above 90% of uranium at 80^{o}C where as ~65% leached vanadium at same temperature
5. The ideal pulp density optimized from present study was 50% for both title metal ions leaching process
6. The ideal conditions optimized for Korean domestic ore sample by present study:

Parameter	Optimized Condition
Time	2 h
Particle size	-48 mesh
Acidity	2 M H_2SO_4
Temperature	80^oC
Pulp density (PD)	50%
Agitation speed	500 rpm

7. Finally, present research paper concludes that, the proper leaching conditions (above said conditions) will full fill the uranium and vanadium leaching process from Korean domestic ore

References

1. E. T. R. Guzman, E. O. Regil, and G. P. Malagon, "Uranium leaching from phosphate rock", *Journal of the Radioanalytical and Nuclear Chemistry Letters*, 201 (1995) 313-320.

2. K. Shakir, M. Aziz, and Sh. G. Beheir, "Studies on uranium recovery from a uranium bearing phosphatic sandstone by a combined heap leaching-liquid-gel extraction process.1 Heap leaching, Hydrometallurgy, 31 (1992) 29-40.

3. E. C. Buck, N. R. Brown, and N. L. Dietz, "Contaminant uranium phases and leaching at the Femald site in Ohio", Environmental *Science and Technology,* 30 (1996) 81-88.

4. A. Yuksel, M. Eral, and S. Olmez, "Leaching of uranium with the H_20_2-Na_2SO_4-H_2SO_4 (HSS) system and the efficiency of acigol lake water", *Journal of the Radioanalytical and Nuclear Chemistry Letters*, 200 (1995) 169-179.

5.H. K. Fouad, "Determination of hexavalent and tetravalent uranium in phosphate ores through hydrochloric acid selective leaching", *Journal of the Radioanalytical and Nuclear Chemistry* 285 (2010) 193-197.

6. S. Klimkova, et al., "Zero-valent iron nanoparticles in treatment of acid mine water from in situ uranium leaching", *Chemosphere,* 82 (2011) 1178–1184.

7. A. C. Patra, et al., "Long-term leaching of uranium from different waste matrices", *Journal of Environmental Management,* 92 (2011) 919-925.

Acknowledgments

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