



## Comparison of Microwave-assisted, ultrasound-assisted and conventional solvent extraction techniques for the extraction of molybdenum with tributyl phosphate

A. Boucherit<sup>1</sup>, H. Khalaf<sup>1\*</sup>, P. Bonete<sup>2</sup>, J. L. Todoli<sup>3</sup>

<sup>1</sup>Laboratory of Chemical Engineering, University of Blida 1, B.P 270, Blida 09000, Algeria.

<sup>2</sup>Department of Physical Chemistry, University of Alicante, B.P 99, Alicante 03080, Spain.

<sup>3</sup>Department of Analytical Chemistry, Nutrition and Food Sciences, University of Alicante, B.P 99, Alicante 03080, Spain

Received 22 March 2019,  
Revised 12 May 2019,  
Accepted 16 May 2019

### Keywords

- ✓ Molybdenum,
- ✓ Solvent Extraction,
- ✓ Microwave,
- ✓ Ultrasound,
- ✓ TBP.

\*Hussein Khalaf :  
[khalafh@hotmail.com](mailto:khalafh@hotmail.com)

### Abstract

The main objective of the current work was to evaluate the feasibility of Microwave-assisted Extraction (MAE) and Ultrasound-assisted Extraction (UAE) techniques as compared to conventional extraction for the extraction of molybdenum from HCl and H<sub>2</sub>SO<sub>4</sub> solutions with TBP dissolved in n-hexane. The results show that the equilibrium time was drastically shortened under MAE and UAE from 10 min to 20 s and 03 min to 20 s for extractions conducted with HCl and H<sub>2</sub>SO<sub>4</sub> solutions, respectively. Increase of HCl concentration increases the extraction yield of molybdenum under MW and UAE irradiations whereas the reverse was observed with the increase of H<sub>2</sub>SO<sub>4</sub> concentration. For 1 M HCl, an increase in microwave power enhances slightly the extraction yield for microwave power greater than 60 W. An increase in ultrasound amplitude has slightly increased the extraction of molybdenum and lowered it for 0.10 M H<sub>2</sub>SO<sub>4</sub>. For a microwave power of 100 W and 1 M HCl, the extraction of molybdenum was 50% higher comparatively to conventional extraction. Also for 1 M HCl and for a pulse amplitude of 80%, the extraction yield was 100% much higher than the one obtained under conventional extraction. The application of MAE and UAE clearly highlights that molybdenum can be extracted by using these technologies and that it has contributed to improve the efficiency of conventional solvent extraction. under suitable process conditions.

## 1. Introduction

The pollution of environment caused by the presence heavy metals became at present a critical and a major problem. This pollution engenders a grave ecological imbalance due to the uncontrolled rejections of the chemical pollutants. Nowadays, the environmental protection is an economic and political stake. Heavy metals resulting from diverse industrial activities often appear at very high concentrations in many of their rejections. The recovery or the elimination of these heavy metals contained in diverse sources is an operation of a great importance for the industry and the environment. Among these heavy metals, the molybdenum is a particularly worrisome case because it accumulates in the body and can cause grave disorders.

In the last years, the commercial value of molybdenum has been significantly increased due to the demand on the part of the emergent economies. Molybdenum is one of the most important metal having compounds encountered in many technological fields. It is well recognized as a strategic metal having many important applications in many industrial sectors [1-3]. Molybdenum is a refractory metal used principally as an alloying agent in steel, cast iron and super alloys to enhance strength and wear and corrosion resistance. Molybdenum finds irreplaceable application in medicinal field i.e. nuclear magnetic diagnosis; analytical field as a target element in XRD; as an alloying element in stainless and construction steel to be used in highly corrosive environment. This metal is generally used in alloys because it contributes to increase the steel resistance at high temperatures and corrosion conditions. Molybdenum is also an essential trace element for plants, animals and humans [4-6]. On the other hand, it can be toxic at high concentrations [4, 5]. This metal is relatively rare in the