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Application of waste frying oil as an extractant for uranium from sulfate leach liquor

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ABSTRACT

The possibility of using the waste frying oil (WFO) as an extractant for uranium from its sulfate liquor has been studied. Several experiments were conducted to determine the relevant factors affecting both the extraction and stripping of the uranium from a synthetic solution. At the optimum conditions, it was found that the maximum uranium uptake would attain 54 mg/g at a solution pH of 3.5. Kinetic characteristics of the loading process have been found to satisfactorily fitting to the pseudo-first-order equation. The obtained optimum conditions have also been applied to investigate the potentiality of the working WFO for the recovery of uranium from the actual sulfate leach liquor of El-Sela ore material (South Eastern Desert of Egypt).

1. Introduction

Increasing interest in environmental protection, economy of energy as well as process optimization and continuous progress in fundamental chemistry have led to the development of new important chemical separation materials e.g. agriculture wastes, fried oil, etc. Used edible oils and fats are indeed considered as a problematic waste product that would contribute to the pollution of the environment. During deep-frying of food at temperatures in the region of 170°–200 °C, the used oil comes under a heavy three-prong attack; namely hydrolysis, oxidation and thermal polymerization. In hydrolysis, the moisture from the food being fried vaporises and hydrolyses triglycerides (TGs) in the frying oil to glycerol, free fatty acids (FFA), monoglycerides (MGs) and diglycerides (DGs). By oxidation, triglyceride molecules in the frying oil would undergo primary oxidation to unstable lipid species called "hydroperoxides" which cleave to form secondary oxidation products which comprise non-volatile and volatile compounds. Some of these secondary products can polymerize (tertiary oxidation); a matter which would darken the oil, increase its viscosity besides browning on the surface (Dana & Saguy, 2001). Finally, in the thermal polymerization, the high temperatures of the frying operation would produce high molecular cyclic fatty acid (FA) monomers, and TG dimers and oligomers Billek (1983), Henry and Chapman (2002), Sikorski and Kolakowska (2002). For these reasons, it is greatly interesting to refer to the fact that biodiesel can indeed be produced from renewable sources such as vegetable oil, animal fat and used cooking oil. The biodiesel (transesterified vegetable oil) has recently attracted enormous attention all over the world as an alternative fuel for diesel engine because of its renewability. Math, Kumar, and Chetty (2010) have

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reviewed the work that has already been done in technologies for biodiesel production from used cooking oil and have also reviewed its fuel properties and their comparison with conventional biodiesel oil. However, the cost of biodiesel is currently high as compared to conventional diesel oil because most of the biodiesel is produced from pure vegetable oil but its cost can be reduced by using low cost feedstock such as animal fat and used cooking oil (waste frying oil: WFO). Since the latter can be used as a source material for manufacturing of methyl esters (ME) as alternative fuels and biodiesel. it can thus be mentioned that the fuel properties of the biodiesel derived from (WFO) are in accordance with biodiesel standards in a manner to be used in diesel engines without any engines modifications. On the other hand, potatoes and other foods that have a high content of the amino acid asparagine and a high accumulation of reducing sugars are subject to the formation of acrylamide upon frying. Acrylamide has the potential to cause a spectrum of toxic effects including neurotoxic effects that have been observed in humans. Acrylamide has also been classified as a "probable human carcinogen" (IARC., 1994).

As a matter of fact, cooking oil when applied for potato frying could result, at least potentially, in the formation of the poisonous acrylamide during the Millared reaction (Mottram, Wedzicha, & Dodson, 2002; Stadler et al., 2004). In the light of these giving's, it was found interesting to investigate the possibility of these products in the extractive hydrometallurgy in a manner to make use of their free fatty acids content.

The present work has thus been formulated to study the potentiality of using the waste frying oil in uranium extraction processes from various solutions. This application is indeed based upon its high acidity which has increased from 3.2 free acidity before boiling to 6.5% after boiling. The latter was thus studied for uranium extraction characteristics from a synthetic uranium solution and the obtained optimum conditions were applied upon El-Sela sulfate leach liquor. To realize this objective, the working frying oil sample was first analyzed before and after its boiling in potato frying, apart from assaying 1070 ppb of the poisonous acrylamide.

2. Materials and method

2.1. Materials

2.1.1. Waste frying oil (WFO)

The working waste frying oil has been obtained from local restaurants after frying potato only and was used as such for uranium extraction from its solutions after having been diluted in kerosene. However, prior to its application as an extractant, it was properly purified with calcium chloride to remove any moisture and possible impurities. In the meantime and for comparative reasons, a fresh sample of this oil has also been collected before being used for potato frying (FFO). Both samples have indeed been subjected to complete chemical analysis for their fatty acid composition using gas chromatography and in the meantime their free fatty acid content has also been determined.

2.1.2. Preparation of the working solutions

A synthetic uranium solution assaying 500ppm has been prepared by properly weighing the required amount of the uranyl acetate salt. The latter was then dissolved in distilled water that has been slightly acidified with dilute sulfuric acid solution. On the other hand, for studying the possible interference from other metal impurities that might be associated with uranium in its solutions, proper weights of some of their compounds have been dissolved in the prepared synthetic uranium solution in a manner to assay 100 ppm for each. The metal compounds used have involed the hydroxides of Fe, Mg and Ca, the nitrate salts of Pb and Th and the chloride salts of Al, Ni, Ce, and Y. Concerning El-Sela uranium mineralization, a sulfuric acid leach liquor has also been prepared thereof using the published optimum conditions.

2.2. Experimental procedures

2.2.1. Uranium extraction procedure

Uranium extraction from either the synthetic uranium solution or that of El-Sela sulfate leach liquor by the working (WFO), has been undertaken after its dilution in kerosene to 10 vol % and addition of ethyl hexanol as a modifier (10%). The experiments were all the time carried out by shaking the two phases in separating funnels. After shaking, the two phases were allowed to settle and the aqueous phase was analyzed for its uranium content and that in the organic phase was calculated by the difference. Several series of experiments were carried out to study the effects of the diluent type, the WFO concentration, the pH, the shaking time, the extraction temp., the interfering metal ions and the A/O phase ratio. On the other hand, the practical saturation capacity of the studied FFO and WFO for uranium has also been determined by using the multiple contact technique.

2.2.2. Uranium stripping procedure

A number of mineral acids, alkalis and acidified NaCl solutions have been used for studying the uranium stripping efficiency from a uranium –loaded WFO sample. For the chosen eluent, both the shaking time and temperature together with the A/O phase ratio have been studied.

2.3. Analytical procedures

2.3.1. Oil characterization

As mentioned above, the working frying oil before and after frying (FFO, WFO) was analyzed for its acid content using the gas chromatography techniques (Berry, 1980). For this purpose, the Hewlett–Packard Gas Chromatograph Type 5 was used. On the other hand, an infra-red analysis has been achieved for the WFO using (FTIR) model Thermo Scientific Nicolet IS10, Germany.

Also, the free acid content of the working frying oil before and after boiling (FFO, WFO) and which would be responsible for uranium extraction has also been determined according to KEM application method (Saad et al., 2007). This has involved the titration of an aliquot oil sample dissolved in ethyl alcohol