



Recovery of rhenium from a molybdenite roaster fume as high purity ammonium perrhenate



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ABSTRACT

Rhenium (Re) was recovered as high purity ammonium perrhenate (APR) from a scrub liquor produced by a pilot plant treating 2000 m³/h of a fume discharged from a molybdenite roaster. The hydrometallurgical process adopted incorporates first a neutralisation stage using lime to remove most of Mo, all Cu, As and other minor contaminants to produce a liquor containing 260–280 mg/L Re and 80–90 mg/L Mo. Solvent extraction was subsequently used to first load the Re and Mo into a 10 v/v.% tertiary amine (Alamine 304–1), 10 v/v.% Isodecanol in 80% Anysol-150. The organic phase which contained typically 6.2 g/L Re and 1.29 g/L Mo was stripped with 30% ammonium hydroxide to yield a liquor containing 29.9 g/L Re and 5.63 g/L Mo. High purity APR (>99.8% purity) was recovered from this liquor by adding sulphuric acid to pH 6.8. The whole process would provide an efficient method to recover at least 85% of Re produced from the roaster, with some loss probably incurred due to the re-condensation and/or re-crystallisation of gaseous Re oxide in the cool part of the fume extraction circuit.

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1. Introduction

Rhenium (Re) has found important application in petroleum and aerospace industries. The world consumption of Re according to Roskill (2010) is mostly in superalloy making (78%), with the remaining 14% used in catalysts and 8% in other applications. Re has been in increasing demand for the production of nickel-based superalloys used in turbine blades of jet engines of which the Re content could reach 6% on average. In the petrochemical industry, platinum–rhenium catalysts are commonly used in the refining of high-octane hydrocarbons required for lead-free gasoline production. Due to its scarcity, rhenium demands a high price (Abisheva et al., 2011; USGS, 2015) varying between 3000 and 5000 USD/kg for catalytic grade ammonium perrhenate (APR) in the period 2010–2014. The world resources of Re reach 2.5 million kg (USGS, 2015) with only 48,800 kg produced in 2014. More than half of this production was from Chile, which has more than 1.3 million kg Re in reserve.

Most rhenium occurs as rheniite (ReS₂) together with molybdenite (MoS₂) in porphyry copper minerals. During processing, the Re value follows Mo and Cu and is recovered together with Cu or Mo sulphide concentrate. Typically, copper or molybdenum sulphide concentrates recovered from flotation circuits contain 50–100 g/t (ppm) Re (Abisheva et al., 2011). Rhenium then departs during Cu smelting or molybdenite roasting mainly in slimes, flue dusts, or

wet scrubbing acid solutions (Kang et al., 2013; Lan et al., 2006; Seo et al., 2012; Shariat and Hassini, 1998; Singh Gaur et al., 2015; Zagorodnyaya et al., 2010).

Ion exchange resins containing tertiary amines such as Amberlite IRA910 and Hostarex A324-loaded resins have been used in several plants for recovering Re (Abisheva et al., 2011). Several studies found that strong or weak base gel resins preferentially adsorb Re compared to the polystyrene macro-structure types (Lan et al., 2006; Mikhaylenko and Blokhin, 2012; Nebeker and Hiskey, 2012). Using weak base resins and 9% ammonium chloride as eluant, 96% Mo could be eluted with only < 1% of Re co-eluted, resulting in a Mo:Re separation ratio higher than 100:1 (Kholmogorov et al., 1999). Strong base anionic resins (Amberlite IRA410 or IRA400) were also used to recover Re from Mo–Re liquors (Mozammel et al., 2007). Gels and bio-adsorbents were recently developed to selectively uptake Mo from Mo–Re effluents (Shan et al., 2012; Xiong et al., 2011).

Several techniques have been proposed for recovering Re from wet scrubbing acid liquors generated during the roasting of molybdenite to produce molybdenum trioxide used in ferro-moly alloy production (Abisheva et al., 2011). Solvent extraction is one of the most popular processes proposed or used in commercial practice. Cao et al. (2009) used a mixture of 20% trioctyl amine (TOA) and 30% tributyl phosphate (TBP) to selectively extract 97% Re and 1.7% Mo from a (15 g/L Mo + 0.1 g/L Re) solution, leaving 4 mg/L Re in the raffinate. Other extractants were also used, including 2,20-(imino)bis(N,N0-dioctylacetamide) (IDOA), di-isododecylamine (DIDA), tri-alkyl (C8–10) amine (Zagorodnyaya et al., 2010), TOA (Ali et al., 2012; Iatsenko Gerhardt et al., 2001; Lou et al., 2010), and tributyl phosphate, TBP (Alamdari et al., 2012;

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