ARTICLE IN PRESS

Waste Management xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Review

Silver recovery aqueous techniques from diverse sources: Hydrometallurgy in recycling

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ARTICLE INFO

Article history:
Received 8 December 2015
Revised 4 February 2016
Accepted 4 February 2016
Available online xxxx

Keywords:
Bio-sorption
Hydrometallurgy
Silver
Recovery
Sources
Silver ion-toxicity

ABSTRACT

The demand of silver is ever increasing with the advance of the industrialized world, whereas worldwide reserves of high grade silver ores are retreating. However, there exist large stashes of low and lean grade silver ores that are yet to be exploited. The main impression of this work was to draw attention to the most advance technologies in silver recovery and recycling from various sources. The state of the art in recovery of silver from different sources by hydrometallurgical and bio-metallurgical processing and varieties of leaching, cementing, reducing agents, peeling, electro-coagulants, adsorbents, electro-dialysis, solvent extraction, ion exchange resins and bio sorbents are highlighted in this article. It is shown that the major economic driver for recycling of depleted sources is for the recovery of silver. In order to develop an nature-friendly technique for the recovery of silver from diverse sources, a critical comparison of existing technologies is analyzed for both economic viability and environmental impact was made in this amendment and silver ion toxicity is highlighted.

Contents

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http://dx.doi.org/10.1016/j.wasman.2016.02.006
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Please cite this article in press as: Syed, S. Silver recovery aqueous techniques from diverse sources: Hydrometallurgy in recycling. Waste Management (2016), http://dx.doi.org/10.1016/j.wasman.2016.02.006

1. Introduction

The singular beauty of silver was well known by human civilization over 6000 years and it played significant roles in various aspects of human life (Syed, 2005; Martin et al., 2009). The global demand of silver has been escalating progressively with the increasing consumption of electronic and electrical equipment (EEE) (Vats and Singh, 2015; Cayumil et al., 2015). In 2014 the global production of silver was 877.5 million ounces (WSS, 2014). Silver is not as expensive as gold or platinum, however less expensive precious metal, silver present limited amounts in earth'scrust and commonly associated with ores of Au, Cu, Pb and Zn (Chansoo and Yufeng, 2012). Generally, silver is obtained from natural sources as co-produce with gold and byproduct with zinc, copper, antimony and lead, etc. from metallurgical processing industries (Lanzano et al., 2006; Salim et al., 2005). In the recent years natural resources of silver are decreasing, the cost of silver productions has risen rapidly and the market price of silver has undergone a decrease in spite of the increased numerous applications such as photography, radiography, electronics, photonics, electrical, catalysis, batteries, jewelry, silverware, dental material, biomedical, medicines, disinfectants in wastewater treatment and food/beverages processes (Huanzhen et al., 2007; Hu-Chun et al., 2012; ATSDR, 1990).

With the growth of all these industries, the recovery and removal of silver have been intensely studied because of his present market demand poses an acute problem of recovery of silver from spent sources by new economically efficient and environmentally clean technologies (Gromov et al., 2004). Meanwhile, the phenomenal increase in the regulations against environmental pollution of silver ion toxicity for the marine, microbial, invertebrate and vertebrate community (including humans) through chains and have caused numerous diseases and disorders (Richards, 1981; Chen and Lim, 2002; Yang et al., 2012). Since it has become of great concern to recover and remove monovalent silver ions (Ag^{+}) from industrial effluents and spent sources, up to ppm level (De Radigues et al., 2010). Moreover, a great interest in silver recovery for both environmental toxicity and economic point of view (Lee et al., 2005; Park and Fray, 2009).

Extraction and recovery of silver were carried out either by hydrometallurgical or biometallurgical routes (Kunda and Etsell, 1985). Leaching represents the first step of the hydrometallurgical route and the recovery of silver by different techniques including cementation, chemical precipitation, adsorption, bio-sorption, electro-coagulation, electro-winning, ionexchange and solvent-extraction, etc. are very important cost-effective silver recovery and extraction process from various silver containing sources. In this article, the evaluation of lucrative and nature-friendly

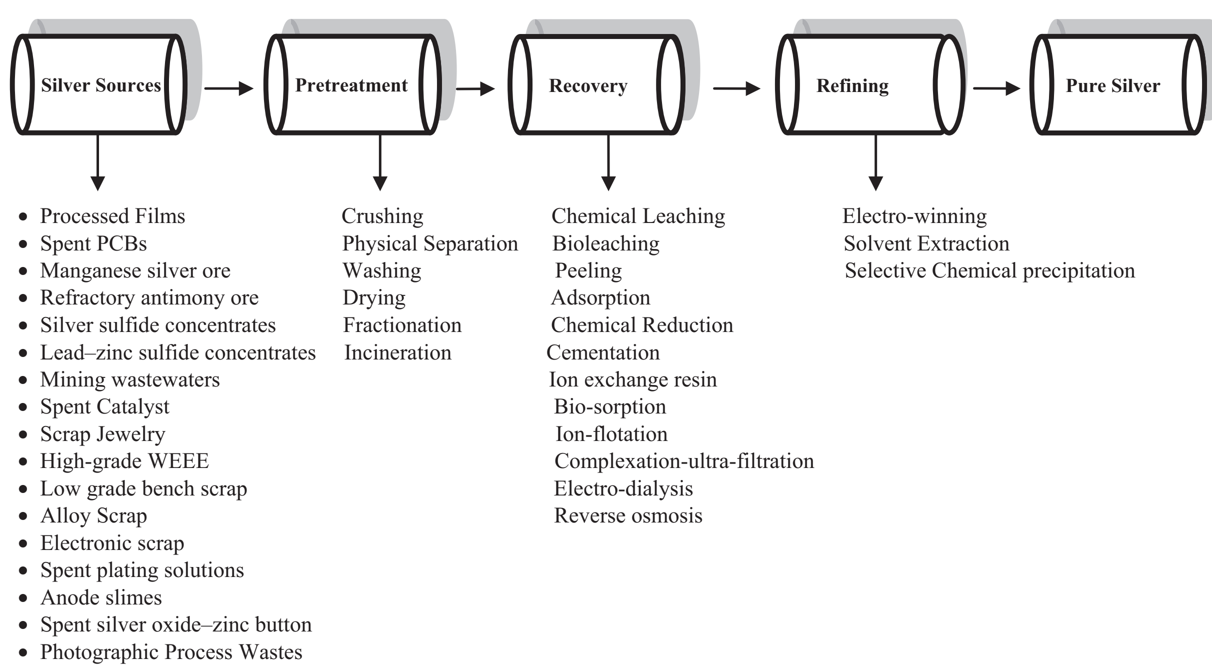

Fig. 1. Silver recovery and recycling basic process flow sheet.

Please cite this article in press as: Syed, S. Silver recovery aqueous techniques from diverse sources: Hydrometallurgy in recycling. Waste Management (2016), http://dx.doi.org/10.1016/j.wasman.2016.02.006