Innovative Scandium Recovery Method from Metallic End Life Products

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Abstract

With the upcoming limitations on gasoline-based vehicles, especially in Europe under the Paris Accord[1], research on lightweight alloys for lower CO_2 emission and efficient electrical cars has peaked. Since Aluminium (Al) is the most abundant metal in the earth crust with no accessibility problems and low price, Al alloys take the lead on design of lightweight alloys. Even though it has several disadvantages such as low strength, incompatibility for welding and low thermal stability, these physical and mechanical properties could be enhanced through alloying.

Scandium (Sc) which is an extremely expensive element for large-scale industrial use at the moment, has attracted attention in the last decade due to property improvements in the alloy and in the energy sector and was hence classified as a critical metal for the future[2-4]. Sc reinforced Al alloys display plentiful advantages over high strength Al alloys and represent a new generation of advanced materials. Addition of minor amount of Sc could tune and enhance the properties of Al alloys, majorly as an outcome of the formation of Al_3Sc phase. Additionally, the mechanical properties of the material could be improved as a result of recrystallization resistance by Sc addition to Al alloys[5]. The problems occurring during welding such as soft spots and loss of strength in heat-affected zones could be eliminated via grain refinement and anti-recrystallization effect during welding. Hot cracking in Al alloy welding could also be eliminated by the use of Sc modified filler material[6].

Sc is the 31st most abundant element with an average Earth crust which makes its rarity comparable with Co and Pb, even though it can be rarely found as concentrated in a mineral. Therefore, major Sc production today is provided via by-products of Ti, U, REEs and Ni and the estimated production of Sc_2O_3 reaches 15tonnes/year[7-9]. Another important source for recycling could be the end life products containing Sc, especially Al-Sc alloys. Nevertheless, there is currently no reported recycling of these materials industrially[10,11] and limited amount of studies

presenting feasible recycling routes[11,12]. Therefore, a complete and sustainable route for Sc recovery from Al-Sc alloys, SCALMALLOY® in this case, was proposed through hydrometallurgical methods in this study.

Conventional leaching of electronegative metallic particles and alloys with a strong mineral acid can result in generation of H_2 gas and an aggressive exothermic reaction. While such a leach process can be made safe at laboratory scale there are significant challenges at commercial scale from a control and zero harm perspective. Thus, an innovative leaching approach was applied with a metal salt solution with higher reduction potential to dissolve the metallic powders with cementation of the metal from the leaching solution. Then, Sc was separated and purified from the impurities by solvent extraction. The end product, ScF_3, is another advantage of the solvent extraction process since it can be directly implemented into Al-Sc alloy or metallic Sc production through molten salt reduction. The process is also scaled up and tested in a continuous mini-pilot scale.

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