European Scandium for a Lighter and Greener Future

Henk van der Laan, Beate Orberger, Carsten Dittrich, Robin Scharfenberg, Edward Peters, Georges Croisé, Pierre Feydi, Carolin Maier, Richard Schneider, Bernd Friedrich, Yashvi Baria, Konstantinos Sakkas, and Christos Georgopolous

Abstract

Scandium is a soft silvery metal, with an atomic number of 21 it is the lightest of the transition metals. The melting point is 1.541 °C, the boiling point is 2.836 °C and with a density of 2.985 g/cm^3 is slightly heavier than Aluminium. Scandium is actually not rare—it is more abundant than precious metals and commercial metals like cobalt, lead and mercury. Scandium is primarily produced as a byproduct from the mining of other metals or minerals like Bauxite, Coal, Rare Earth Elements (REE), Iron, Tungsten, Uranium, Zirconia or Titanium-dioxide. Scandium and scandium compounds have unique properties for many advanced technological applications. Scandium is considered as a Strategic metal by the EU and by the US government due to the current limited Western supply situation. Scandium is increasingly used in energy storage systems such as solid oxygen fuel cells (SOFC) and for green hydrogen production in solid oxide electrolyser cells (SOEC). AlScN piezoelectric films for energy generation are important compounds for 5G applications. Today, the EU imports 100%, mainly from China. Therefore, a continuous supply of scandium at reasonable prices must be ensured in and for Europe, and the dependency on China must be reduced. Europe is leading in the development of green technologies and has sufficient scandium resources. This paper will briefly explain the status and potential of Scandium compound production in Europe, in particular providing an update on the ScaVanger project.

H. van der Laan (✉) · B. Orberger · C. Dittrich · R. Scharfenberg · E. Peters · G. Croisé · P. Feydi · C. Maier · R. Schneider · B. Friedrich · Y. Baria · K. Sakkas · C. Georgopolous
Rotterdam, The Netherlands
e-mail: henkvanderlaan@yahoo.com

Scandium Properties

Scandium (Sc) is a soft silvery metal, with an atomic number of 21, it is the lightest of the transition metals. The melting point is 1.541 °C, the boiling point is 2.836 °C and with a density of 2.985 g/cm^3 is slightly heavier than Aluminium. Thermal conductivity of Scandium is 15.8 W/(m·K). The linear thermal expansion coefficient of Scandium is 10.2 µm/(m·K).

The high melting point makes Sc interesting for many applications, especially for high strength light alloys.

Scandium Resources

Scandium is actually not rare—it is more abundant [1] than precious metals and commercial metals like cobalt, lead and mercury. Scandium rarely concentrates in nature [2, 4], therefore a primary scandium mine is not available. Scandium is primarily produced as a byproduct from the mining of other metals or minerals like Bauxite [5], Coal, Nickel laterites, Rare Earth Elements (REE), Iron, Tungsten, Uranium, Zirconia or Titaniumdioxide. Scandium occurs in aqueous acidic residual solutions from metallurgical processing.

Today, Europe imports 100% scandium oxide (Sc_2O_3). Major suppliers are located in China (~67%), Russia and Kazakhstan.

Scandium Applications and Markets

Scandium and its compounds have unique properties [3] for many advanced technological applications. Scandium is considered as a strategic metal by the EU and by the US government due to the current limited Western supply situation. Scandium is increasingly used in energy storage systems such as solid oxygen fuel cells (SOFC) and for green

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hydrogen production in solid oxide electrolyzer cells (SOEC). Mg-Sc alloys are mentioned as a promising light weight application for hydrogen storage.

For aluminium and its alloys, AlSc2 is a strong grain refiner, it is also an alloying ingredient resulting in improved mechanical properties in Al–Mg-Zr alloys. It has a positive effect on the weldability of Al–Mg alloys [6], these alloys are extremely suitable for marine and aerospace applications. The “Green” aerospace alloy 5024 (AlMg4.5Sc0,2) has ideal properties to be used in existing commercial planes for fuselage panels as a replacement of the traditional 2024 aircraft alloy resulting in a 4–5% weight saving. Other promising applications of Al–Mg-Sc alloys are LPG tankers and windmill rotor blades. Al-Sc-N piezoelectric thin film depositions in the semicon industry are important compounds for 5-G and 6-G applications and for power electronic applications.

Summarising, Aluminium-scandium alloys, scandium oxides and fluorides can play a major role in our energy transition and innovative technologies to reduce CO_2 footprints.

Future European Production

Today, the EU imports 100%, mainly from China ($\sim$67%) as scandium oxide (Sc_2O_3). This lack of a reliable and sustainable supply chain for scandium prevents a broader use of Sc-applications. Therefore, a continuous supply of scandium at reasonable prices must be ensured in and for Europe, furthermore, the dependency on China must be reduced.

Europe can become a leader in the growing market applications covering the entire value chain when a continuous scandium supply is ensured. Europe’s tradition in extractive metallurgy provides the know-how and experience of scandium production.

The lack of a primary scandium mine in Europe opens the door for industrial symbiosis processes for the winning of Scandium precursor from industrial residues like scandium containing waste acid from other industries (Titanium, Nickel and Aluminium). Europe is leading in the development of green technologies and has sufficient scandium resources. These resources indeed are presently locked in metallurgical residues. They are hosted in residual iron-chloride or sulphate solutions from titanium oxide (TiO_2) pigment production. Each year, about 1.5 million tons of TiO_2 are manufactured in Belgium, Germany, the Netherlands, Slovenia and the United Kingdom. The waste acids are neutralised and either landfilled at high costs and causing environmental risks, or, in some plants, sold as a product to the chemical industry.

ScaVanger Production

The two EIT-Rawmaterials projects; ScaVanger (2021–2024) and Scaleup (2022–2024)* will bring Scandium compounds and a Scandium Aluminium alloy to the market. Scandium, Niobium and Vanadium will be extracted through hydrometallurgical processing “in-line” from acid residual solutions during metallurgical processing of the Titanium dioxide. ScaVanger is an industrial symbiosis (IS) project for the winning of Sc, Nb and V from industrial residues out of the Titaniumdioxide pigment industry. Scaleup is an IS project for the winning of Sc, Ga and V from red mud, which is industrial waste from Alumina production.

The ScaVanger’s ecological and economical processing includes acid and water recycling, as well as metal recoveries during the cleaning process. This industrial symbiosis process converts residue to valuable products—economically and ecologically-friendly. ScaVanger’s business model is focussed on Scandium hydroxide first. ScaVanger intends to produce a Scandium precursor in the form of a Scandium hydroxide filtercake. This feedstock will be converted into several Scandium compounds to serve different Sc markets.

1. Scandium hydroxide.
2. Scandium oxide and scandium fluoride corresponding to about 45 tons per year equivalent to scandium oxide for the European market.
3. AlSc alloys in mass production to supply to specialized Al-Sc-Mg producers.

Upscaling of metallurgical processing to preindustrial production will be performed for 3 years from both resources: iron-rich chloride solutions (TiO_2 production in the EU) and residue (alumina production at MYTILINEOS S.A, Greece). This scandium production will start up-ramping in 2025. The concepts can be adapted and exported to other TiO_2 and Al processing plants in and outside the EU (Fig. 1).

Conclusion

Sc-compounds (Aluminium-scandium alloys, scandium-hydroxide, -oxide and -fluoride) production in Europe can play a major role in the energy transition and development of innovative technologies to reduce CO_2 footprints.

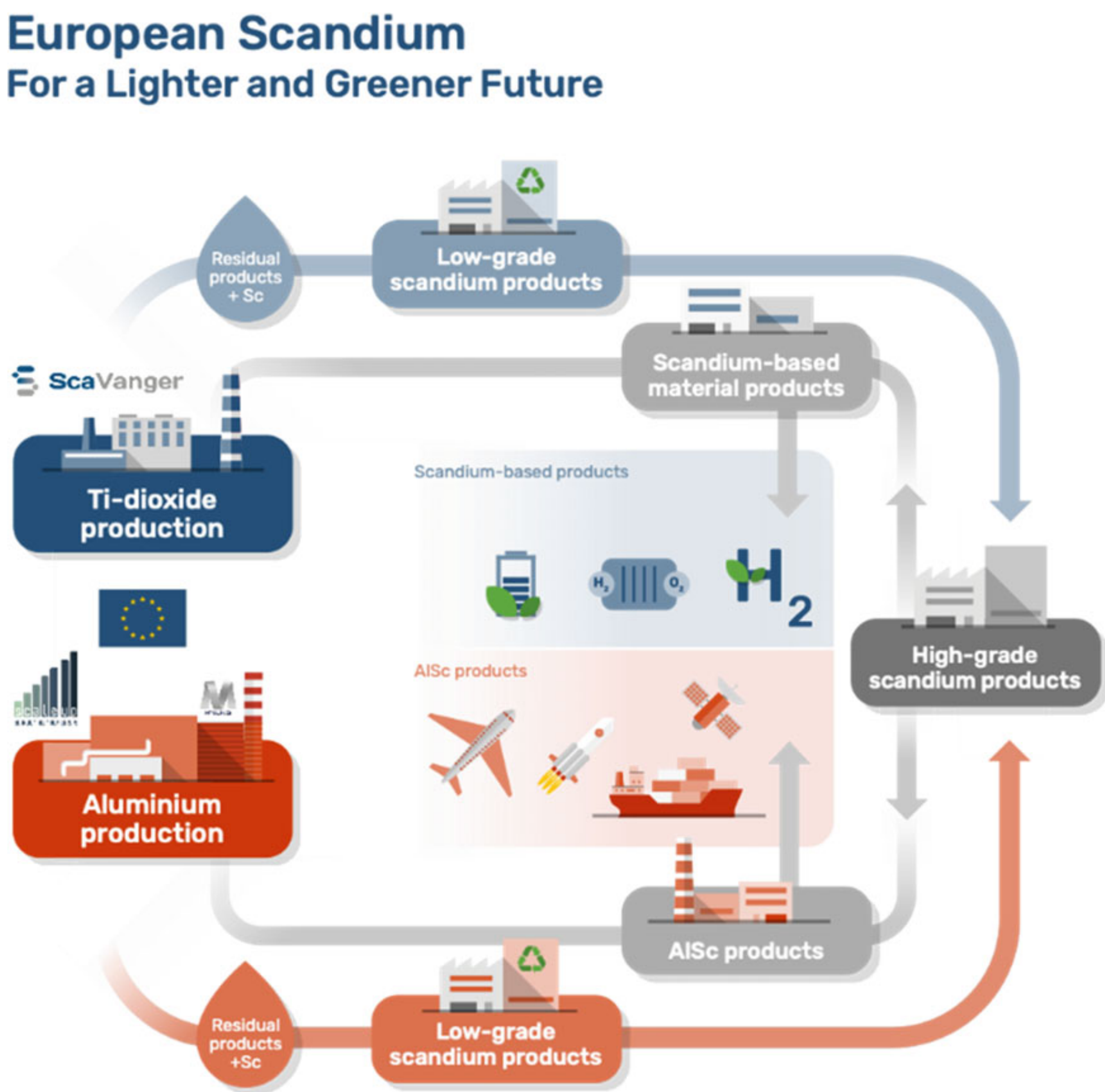

Fig. 1 Schematic of The ScaVanger and Scaleup projects, which are co-funded by EIT Raw Materials (https://eitrawmaterials.eu/). Contact: Beate Orberger, Catura Geoprojects: beate.orberger@catura.eu

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