PhD Open Days

Recovery of rare earth elements from CRT phosphors

Chemical Engineering Doctoral Programme

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Introduction

Rare earth elements (REE) are a series of 17 chemical elements characterized by specific optical and magnetic properties, causing them to be critical to niche applications. Phosphors are important components widely used in electric and electronic devices including televisons and other monitors, fluorescent lamps and LEDs.

Cathode-ray tube (CRT) colour screens, as it can be observed in **Figure 1**, typically consist of mixtures of Y_2O_3:Eu^{3+} or Y_2O_2S:Eu^{3+} to emit the red colour, ZnS doped with Cu or Al to emit green, and ZnS doped with Ag or Ni to emit in the blue spectrum[1]. A few other elements (Al, Si, K, Ca, Sr, Ba, Pb) have been reported in waste phosphor fractions, mainly a consequence of contamination with other components of the waste[2]. Recycling REE from these residues is very beneficial from the environmental point of view, to wit the avoidance of radioactive dust release that arises from traditional REE ore mining.

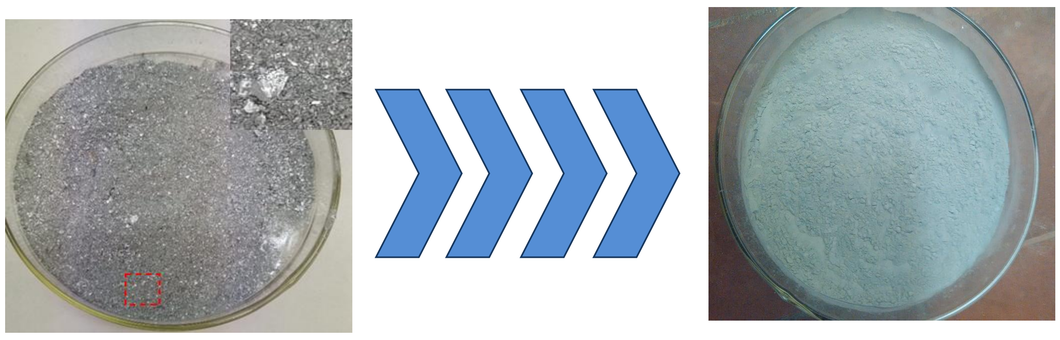


Figure 1 Representative picture of an impure mixture of CRT phosphors (at the left, magnification in the red rectangle on the top)

Leaching of REE

CRT Phosphors mixture was distributed between eight jars using a Retsch DR100 with a vibratory feeder. A portion of the homogenized material was sieved and the fraction under 38 μm was used for upcoming studies because it was observed to have higher content on REE and free of the main contaminants. Sieved phosphor powder was added to a round bottom flask with a stirring bar. Water, nitric acid and hydrogen peroxide were added. After 5 hours of stirring, the suspension was filtered. **Figure 2** illustrates the beginning and the end of the leaching.

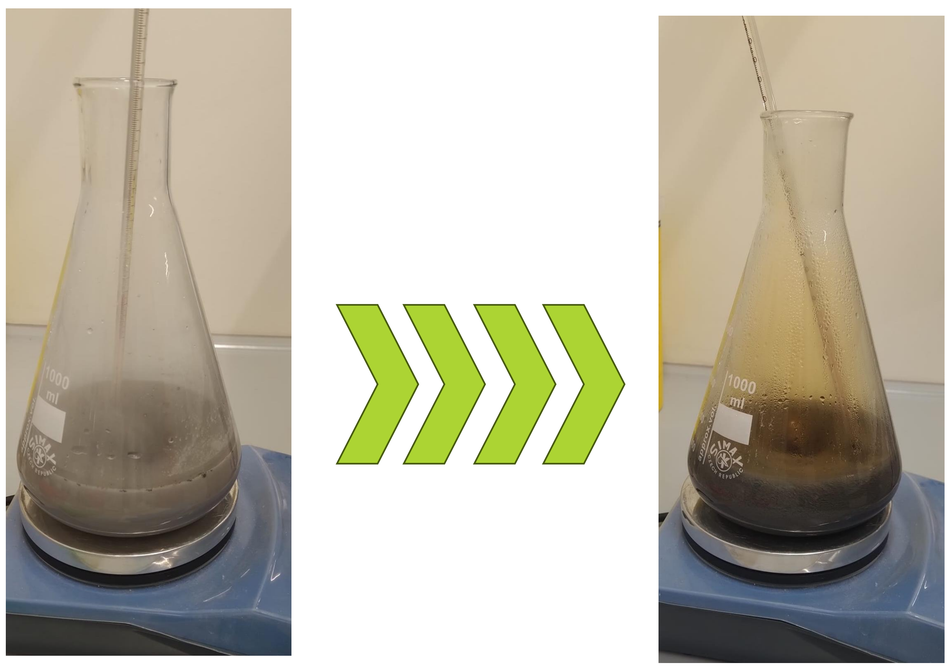


Figure 2 Ilustration of the start of the leaching of the phosphors (at the left) and after 5 hours of reaction time (at the right).

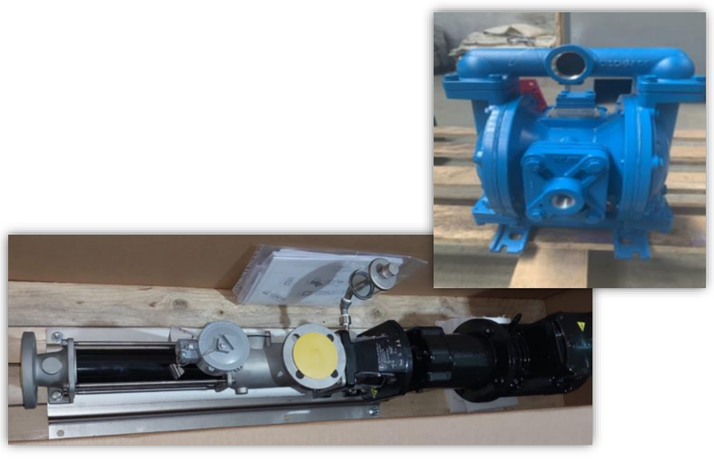
Precipitation and calcination of REE

After the leaching process and filtration, oxalic acid was added to the leaching solution. The suspension was left to react for 5 minutes. The mixture was left to settle for 30 min and it was filtered. The precipitated oxalates were calcined at 850 ºC for 6 hours to afford the rare earth oxides. Both powders can be observed in **Figure 3**. The global recovery of yttrium and europium were 65.2% and 55.6%, respectively.

Figure 3 Representative pictures of yttrium and europium oxalate decahydrate (at the left) and yttrium and europium oxides (at the right).

Pilot plant for the recovery of REE

Reactors



Pumps

Filters

Furnace

Conclusions

- Sieving removes main impurities (Al, Si, Sr, Ba, Pb) and concentrates REE in the < 38 μm fraction;
- Leaching dissolves more than 80% of Y and Eu;
- Global recovery on REE from sieved phosphors is 65%;
- A pilot unit for the recovery of rare earth elements has been projected and is currently under construction.

[1] F. Forte, L. Yurramendi, J. L. Aldana, B. Onghena and K. Binnemans. *RSC Adv*., 2019, **9**(*3*), 1378–1386. DOI:10.1039/c8ra08158a

[2] A. Lixandru, P. Venkatesan, C. Jönsson, I. Poenaru, B. Hall, Y. Yang, A. Walton, K. Güth, R. Gauß and O. Gutfleisch, *Waste Manag*. 2017, **68**, 482–489. DOI:10.1016/j.wasman.2017.07.028

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