Properties of Garnet Type Phosphors in Dependence on the Synthesis Route

Jan-Niklas Keil, Elisa Lindfeld, and Thomas Jüstel
Münster University of Applied Sciences, Department of Chemical Engineering
Stegerwaldstrasse 39, D-48565 Steinfurt, Germany
Corresponding authors: keil@fh-muenster.de *and* tj@fh-muenster.de

22nd JCF Frühjahrssymposium, March 26-28, 2020, Cologne, Germany

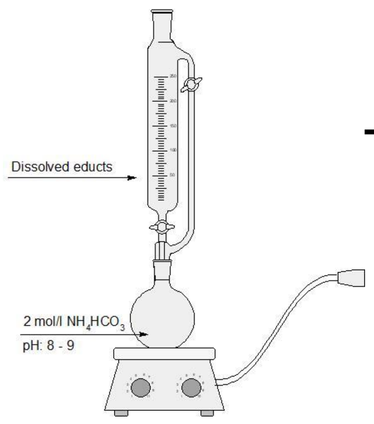
Introduction

All roads lead to Rome, but sometimes none. Any chemist who is confronted with a synthesis task will probably understand this slightly modified proverb. Some compounds can be produced very easily and in many different ways, others are almost impossible and, if they are, only accessible with great effort. Before you start the first synthesis, there is always the question:
"How to prepare the desired target compound?"
Once this question has been clarified, a second question often arises:
"What influence can I exert on certain product properties, by skilfully selecting the preparation conditions? This contribution will use $Y_3Al_5O_{12}:Pr^{3+}$ ($YAG:Pr^{3+}$) and $Lu_3Al_5O_{12}:Pr^{3+}$ ($LuAG:Pr^{3+}$), two garnets well studied in literature, to illustrate the influence of different synthesis routes on different product properties.

Synthesis

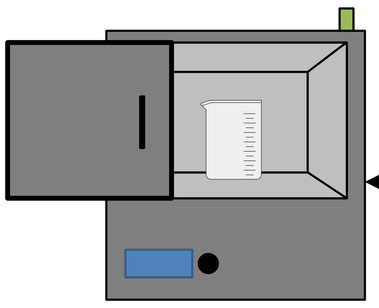
The phosphors were produced by three methods, which are standard procedures in the synthesis of inorganic phosphors. These are a precipitation reaction and two different combustion methods (hereinafter referred to as citrate and combustion method).

Precipitation:



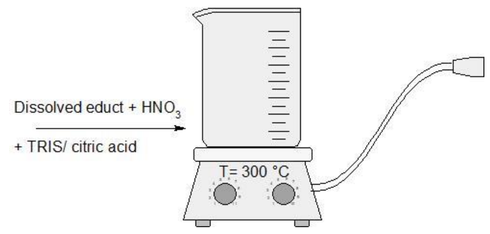
Drying → Grinding → Pre calcination
800 °C, 4 h, 120 °C/ h, air
→ Grinding → Calcination
1600 °C, 4 h, 200 °C/ h, air

Combustion



Drying → Citrate

Combustion/ Citrate:



Combustion: TRIS (complexing agent and fuel); Reaction (in the beaker)
Citrate: Citric acid (complexing agent); Reaction (in the oven)

The educts precipitate as hydroxy carbonates

TRIS = Tris(hydroxymethyl)-aminomethane

Results and Discussion

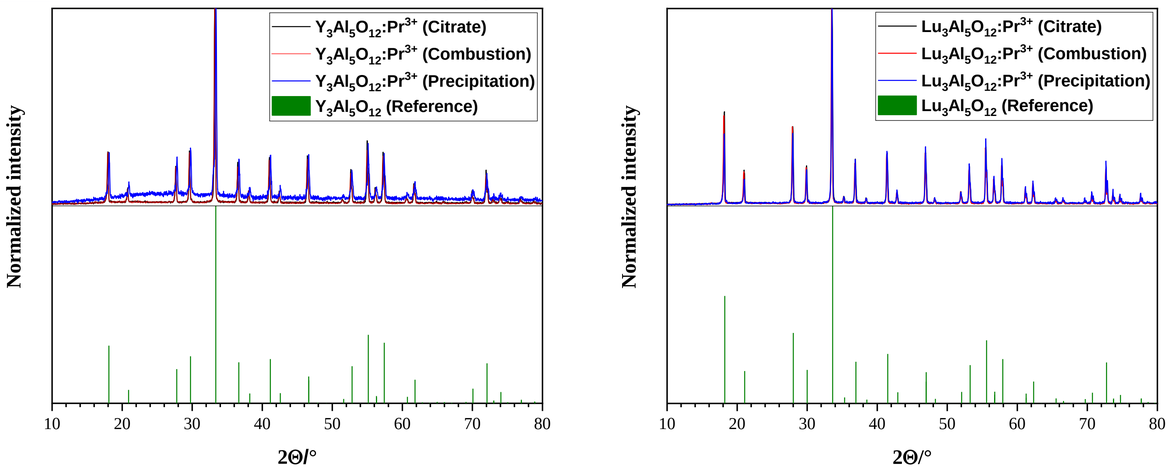


Fig. 1: Powder X-ray diffraction pattern of $YAG:Pr^{3+}$ (left) and $LuAG:Pr^{3+}$ (right)

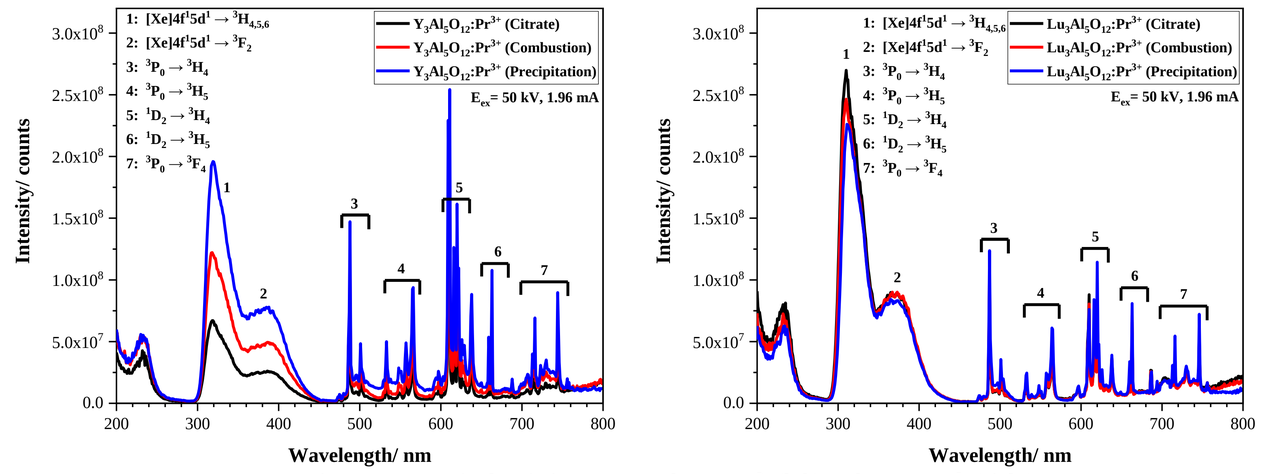


Fig. 2: X-ray excited emission spectra of $YAG:Pr^{3+}$ (left) and $LuAG:Pr^{3+}$ (right)

- **The powder X-ray diffraction patterns prove that all methods allow access to single phase $YAG:Pr^{3+}$ and $LuAG:Pr^{3+}$ samples.**

- **In the case of $LuAG:Pr^{3+}$, the X-ray excited emission measurements show that all methods lead to samples with nearly equal emission spectra. However, a closer look at the $YAG:Pr^3$ samples shows that, depending on the preparation method, the emission intensities vary between 300 and 450 nm.**

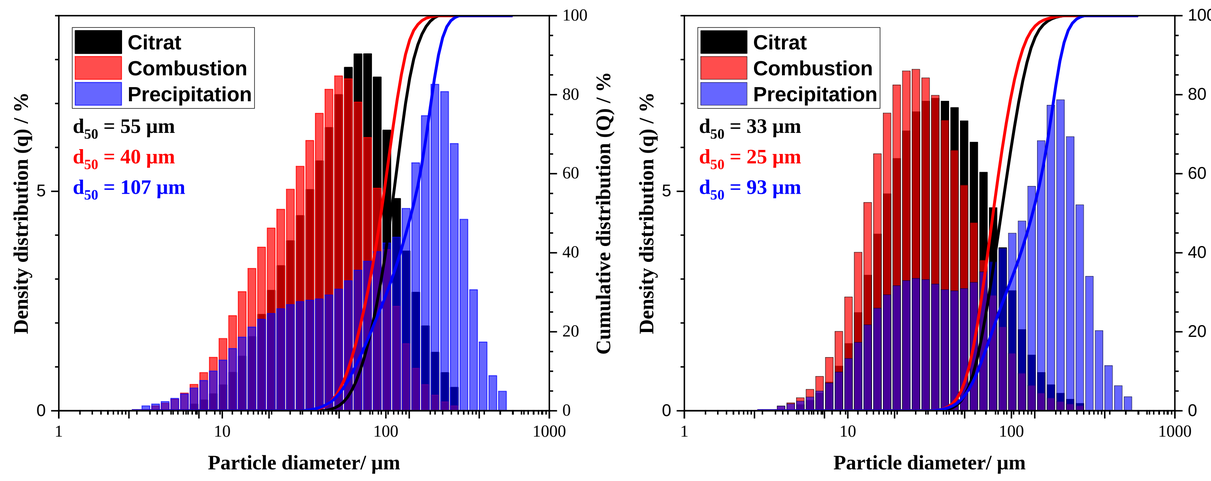


Fig. 3: Particle size distribution $YAG:Pr^{3+}$ (left) and $LuAG:Pr^{3+}$ (right)

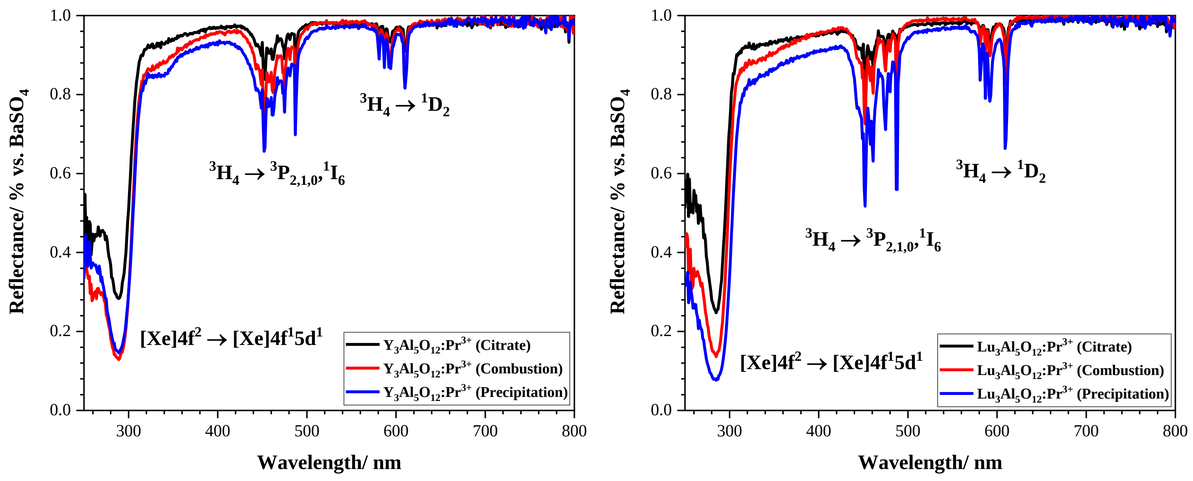


Fig. 4: Reflection spectra of $YAG:Pr^{3+}$ (left) and $LuAG:Pr^{3+}$ (right)

- **The particle size distributions of the samples differ significantly. Combustion and citrate methods lead to monomodal, precipitation to bimodal particle size distributions. For both phosphors the combustion led to the smallest particles and the precipitation to the largest particles.**

- **The reflection properties of the samples also differ slightly. For both compounds the citrate samples show the highest reflectivity over the measured spectral range, the precipitation samples the lowest.**

Conclusions

All three methods presented enabled access to single phase samples. The prepared samples showed nearly identical spectroscopic properties. Only the reflection measurements showed small differences, as well as the emission spectra of the $YAG:Pr^{3+}$ samples. Tremendous differences as expected are observed with respect to particle size distributions.