Mixed Fuel Combustion Synthesis of Yttrium Aluminum Garnet (YAG)

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Introduction

Yttrium aluminum garnet (YAG) doped with cerium (Ce) fluoresces when irradiated by photons

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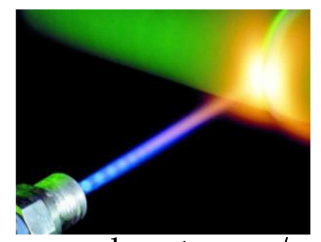
YAG:Ce is used in LEDs (left) and lasers (right)



www.laserto.com/

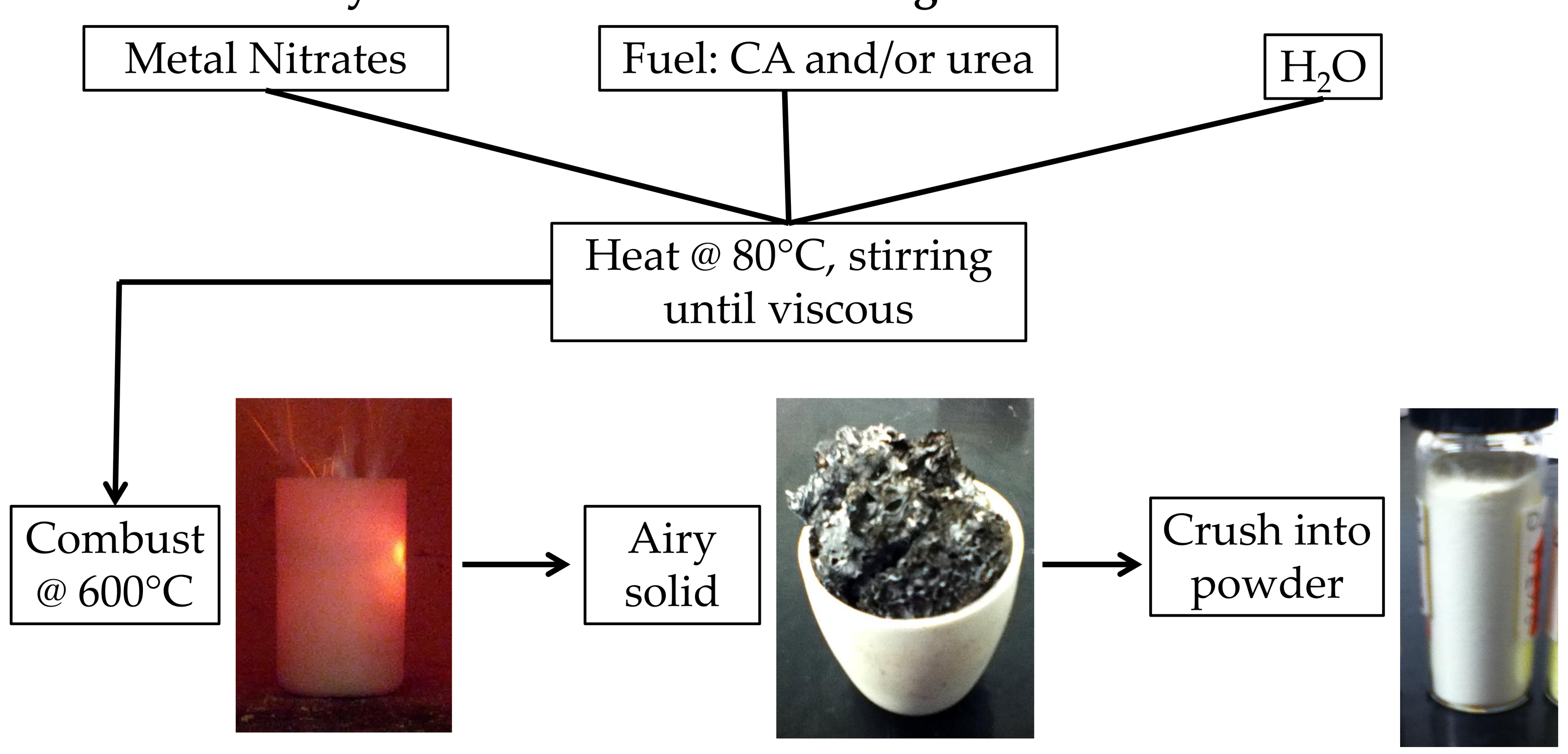
High quality material is required for the proper functioning of devices using YAG:Ce. Combustion synthesis is one potential method to create YAG, but requires more optimization. We have considered optimizing the process by using multiple fuels to produce YAG. The fuels have different strengths:
•Citric acid (CA) distributes dopant well within YAG solution
•Urea produces high flame temperature, crystallizing YAG upon formation

We hope mixing fuels will produce crystalline YAG:Ce1% with a high fluorescence intensity due to well distributed dopant in the crystal.

Objectives:
•Determine the effects of combusting YAG:Ce1% using a mixture of citric acid (CA) and urea in six various fuel ratios on YAG:Ce1% properties
•Determine the effects of post-synthesis heat treatment (HT) on the fluorescent intensity and crystal structure of YAG:Ce1%

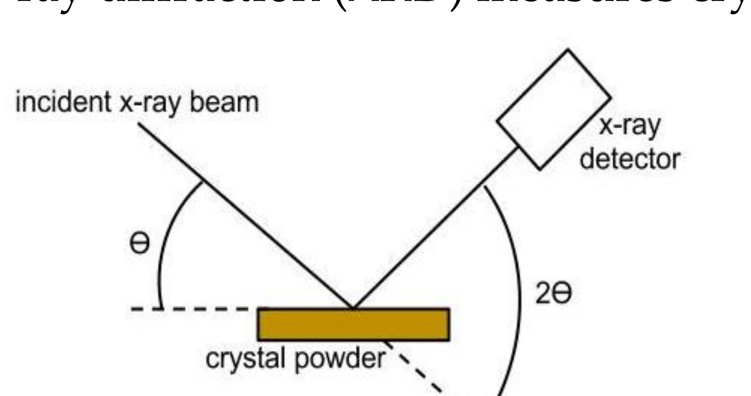
Methods

1. Combustion Synthesis of YAG:Ce1% Using Mixed Fuels



2. Characterization of YAG:Ce1%

Two characterization tests were done on the YAG:Ce1%:
•Photoluminescent spectroscopy (PL) measures intensity of the fluorescence
•X-ray diffraction (XRD) measures crystal structure of the YAG:Ce1%

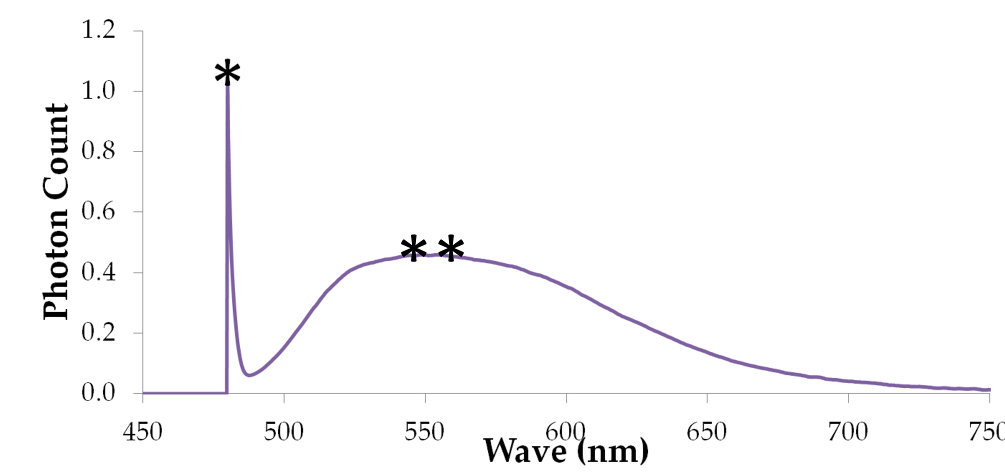


Schematic of XRD testing

XRD on YAG:Ce1%, 100% CA

Results

1. Photoluminescent spectroscopy (PL)

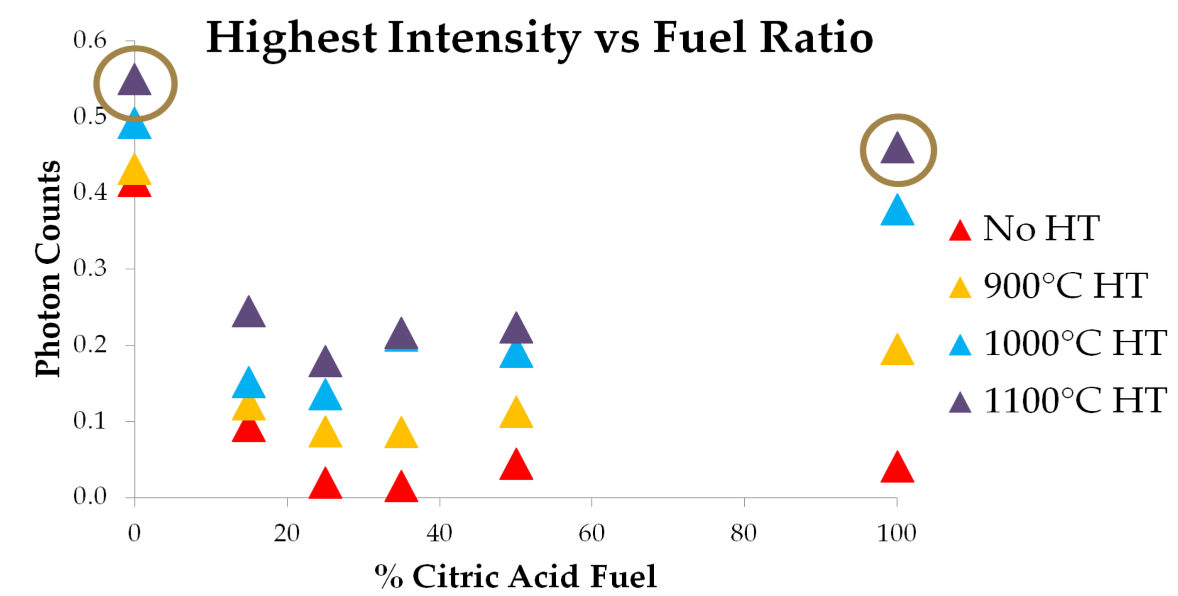


(Left) PL spectra of YAG:Ce1% combusted with 100% CA, post 1100°C HT.

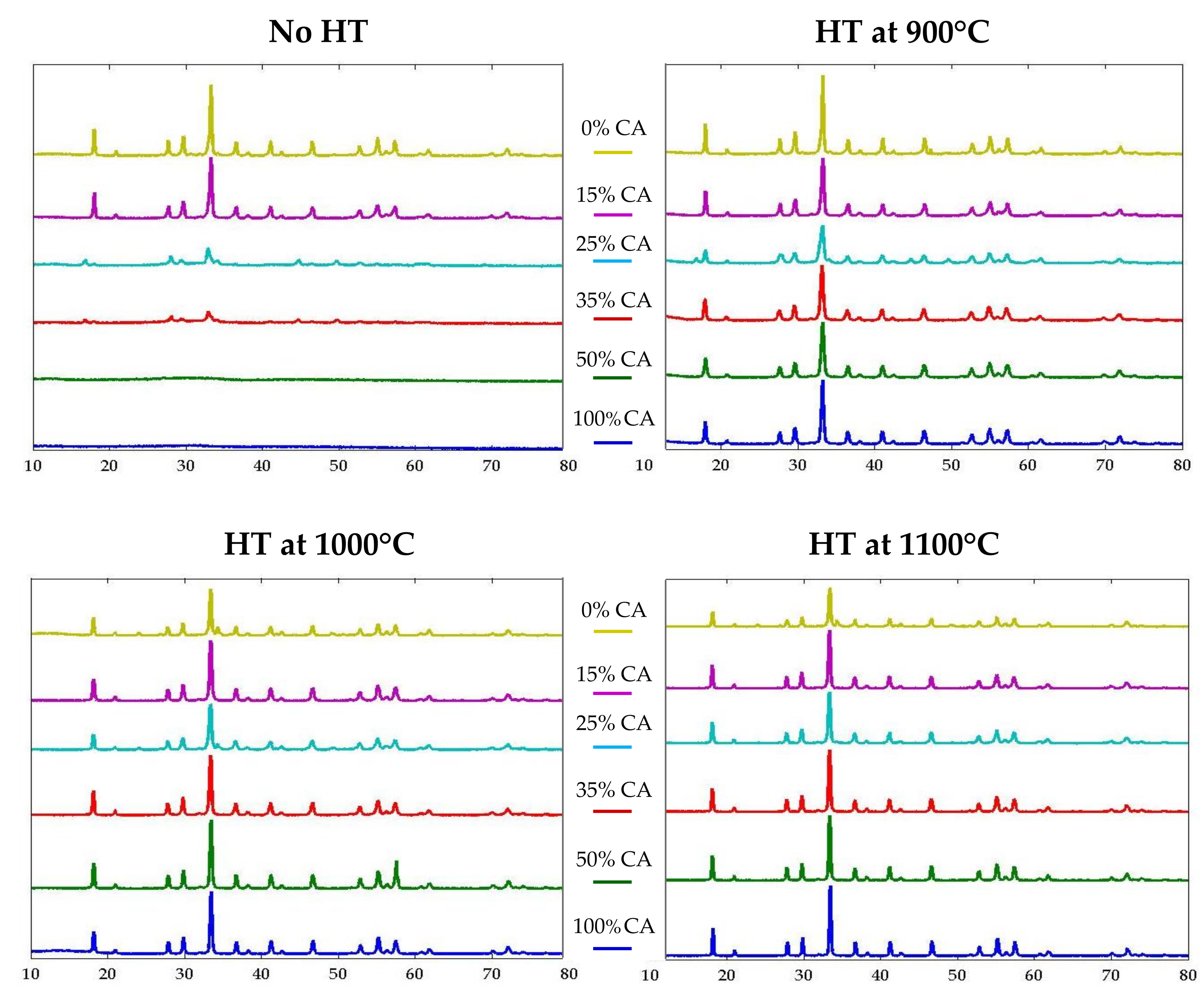
* excitation peak intensity, point PL data was normalized to

** highest intensity, graphed (below) after normalizing

(Right) Highest two PL values are circled in gold. These both appeared in pure fuels (100% CA and 100% urea)



2. X-ray diffraction (XRD)



Discussion/Conclusions

YAG:Ce1% produced with 100% urea has
•the highest PL intensities for all HT studied
•the most crystalline material pre-HT

YAG:Ce1% produced with 100% CA has
•the second highest PL intensity, after 100% urea
•no crystalline material pre-HT

YAG:Ce1% produced with a mixture of fuels has
•a range of PL intensities, with no specific trend
•increasing initial (pre-HT) crystallinity with increasing percentages of urea fuel used

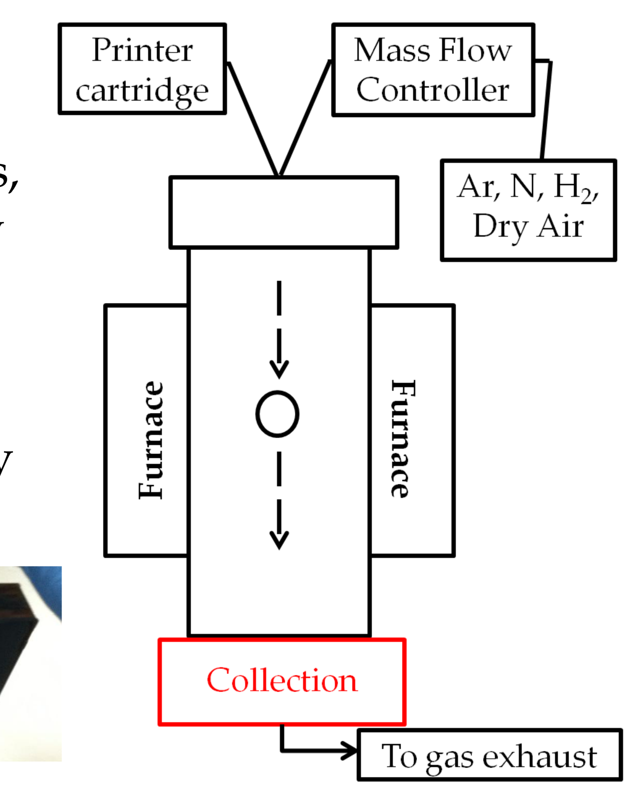
As HT temperature increases
•PL intensity increases
•crystalline structure within the material increases

The target properties of YAG:Ce1% are optimized when 100% urea is used during combustion. Mixing fuels did not improve the measured results.

Future Work

Combustion synthesis produces inconsistent YAG:Ce1% particle sizes, which are based on how fine the YAG is crushed after combustion.

Future work will modify an ink cartridge around which a continuous process can be developed.



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