# Synthesis of Labeled Nanoparticles to Investigate Environmental Transport and Fate

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## Objective:

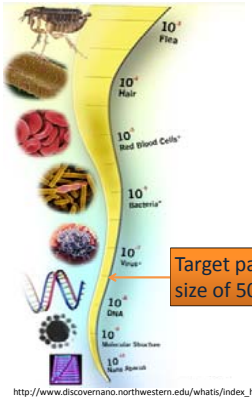
The goal of this project is to produce a method of tracking titanium dioxide ($TiO_2$) nanoparticles through the environment. This will be done by creating a core and shell nanoparticle that uses lanthanum oxide ($La_2O_3$) as the core and $TiO_2$ as the shell.

## Purpose:

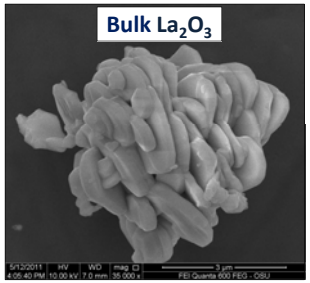
Track the transport of $TiO_2$ nanoparticles because they may have adverse health effects in humans and are frequently produced in industrial processes. A core and shell particle is used so that the nanoparticles can be distinguished from the naturally occurring $TiO_2$.

The $La_2O_3$ core will be a good emitter of gamma rays when exposed to neutron bombardment, allowing us to track the nanoparticles. Coating the $La_2O_3$ with $TiO_2$ should allow the particles to behave and move like pure $TiO_2$.

## Perspective

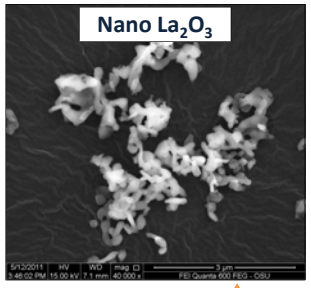



http://www.discovernano.northwestern.edu/whatis/index_html/howsmall_html




## Nano $La_2O_3$ Synthesis:

1. Dissolve $La_2O_3$ in nitric acid.
2. Filter the solution and add polyethylene glycol (PEG).
3. Heat the solution in a water bath.
4. Dry in an oven, mill, and then burn/calcine in a furnace.




Dissolve 2.8 grams of lanthanum oxide bulk powder in 32 ml of 23.1 % nitric acid.

Filter the solution using vacuum filtration and 450 nm filter paper.

Dissolve 1.09 grams of PEG in the filtered solution.

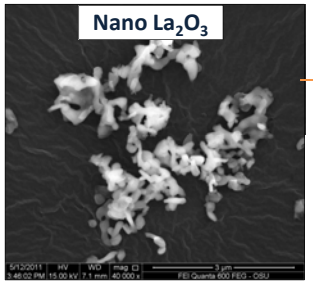
Heat the mixture at 90 °C for 170 minutes in a water bath. Leaving behind a "gel."

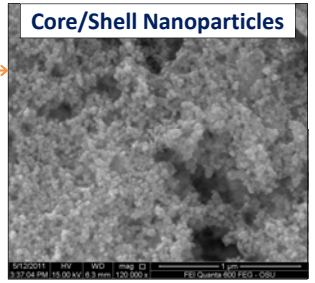
Dry the "gel" at 92 °C for 86 hours and 15 minutes, forming lanthanum nitrate.

The lanthanum nitrate is then milled using a mortar and pestle.

The lanthanum nitrate is burnt at 300 °C for 30 minutes, forming lanthanum carbonate.

The lanthanum carbonate is then calcined at 850 °C for 180 minutes forming lanthanum oxide.




## $TiO_2$ Coating of $La_2O_3$ :

1. Add 0.04 g $La_2O_3$ to 20 ml ultrapure water.
2. Add 0.21 g of $Ti(SO_4)_2$ to 25 ml ultrapure water.
3. Place $La_2O_3$ solution in ice bath at 10 °C.
4. Add $Ti(SO_4)_2$ solution to $La_2O_3$ solution at a 0.16 ml/min.
5. Stir mixture at 10 °C for 180 minutes and age at room temperature for 24 hours.

## Results:

X-ray diffraction (XRD) demonstrates that $La_2O_3$ was the product prior to the coating process.

A scanning electron microscope (SEM) was used to analyze the coated particles. SEM imaging showed that large agglomerates of particles with an average diameter of 20 nm formed while x-ray analysis resulted in an average molar particle composition of 84.2% $La_2O_3$ and 15.8% $TiO_2$.

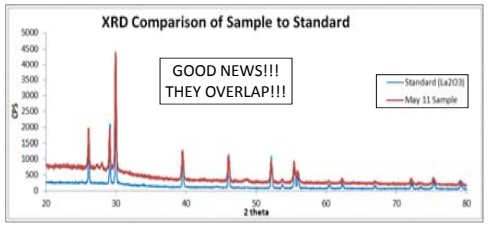



***Figure 1:*** *The plot above indicates the XRD curve for known lanthanum oxide, which is represented by the blue line. Our sample is represented by the red line. X-ray diffraction produces a unique set of curves for each compound, which means that if our sample was not lanthanum oxide, then it would have multiple peaks that do not line up with the standard.*

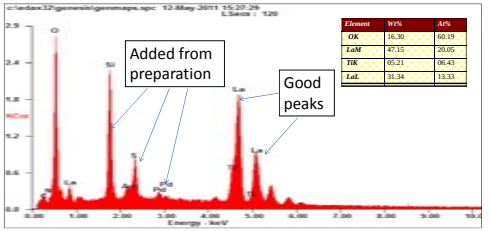



***Figure 2:*** *The plot above is the elemental analysis of our coated particles via SEM. The peaks are labeled based on which element it corresponds to. The intensity of the peaks are associated with the concentration of that particular element. There are some elements present that are not part of our sample but were introduced due to the preparation of the sample for viewing with the SEM.*

## Future Work:

- TEM imaging for a core/shell photo.
- Shear particles Quadra 3D dual beam SEM to further image core/shell particles.
- Re-attempt coating process using ethanol as solvent to prevent agglomerating.
- Optimize Ti concentration to prevent excess Ti in final product.

## Acknowledgements:

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