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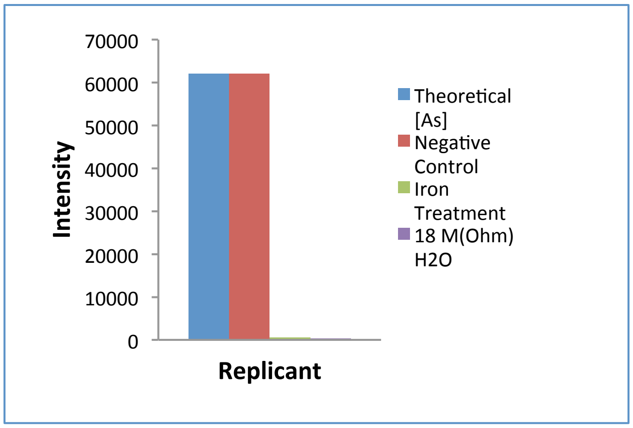
Project Title: Hazard Characterization and Life-cycle Based Green Design of Nanotechnology-Enabled Product

Iodine deficiency has emerged as the number one preventable cause for mental illness in children in developing countries. A test in the form of a paper analytic device (PAD) can detect iodine in urine, which would provide more efficient targeting of aid to those in need. Identification and characterization of potential harms at any stage of the product life cycle is part of green design. Evaluation of the urinary iodide PAD in this way reveals considerable risk in addition to the potential benefit to human health. Some of the key ingredients in the test, trivalent and pentavalent arsenic, could lead to significant environmental damage if not disposed of properly. In order to combat these risks, this project has explored the usage of iron oxide nanoparticles to adsorb the arsenic, immobilizing it and thus removing its toxicity after disposal. All my work was carried out at the University of Notre Dame and is a continuation of my work from my NDnano NURF from 2012, “Ethical, Societal, and Health Implications of Complex Engineered Nanomaterials – A Life Cycle Approach”. My project consisted of three major parts:

1. Inductively Coupled Plasma (ICP): ICP tests the relative concentrations of various elements in a solution by vaporizing a sample, igniting it into a plasma, and measuring the optical emissions of the sample’s electrons at various wavelengths. ICP allowed us to quantify how much arsenic was being leached out of the PADs into the local environment as well as see how much of an effect the various treatments were having on the arsenic concentration. The results of idealized *in situ* analyses show that iron oxide has a high affinity for arsenic, lowering the concentrations of arsenic residues to below EPA and WHO standards of 5 ppm.
2. Characterization: the term “iron oxide” is very general, and many different mineral phases can arise from the synthesis protocols our lab has been using. As a result, we have explored different analytical techniques such as particle surface area analysis (BET), X-ray powder diffraction spectroscopy (XRD), and atomic force microscopy (AFM) to determine the nature of our product. Results of these analyses show that our current iron oxide phase is magnetite, a common and relatively innocuous ferromagnetic compound.
3. Product Design: the results of our ICP-OES analysis have shown that under idealized conditions iron oxide has a high affinity for arsenic. Current research involves incorporating the synthesis protocol into the design of the urinary iodide PAD. Work in this area is entering the final stages of data analysis and our lab group is currently making plans on drafting a manuscript for the publication of our findings.



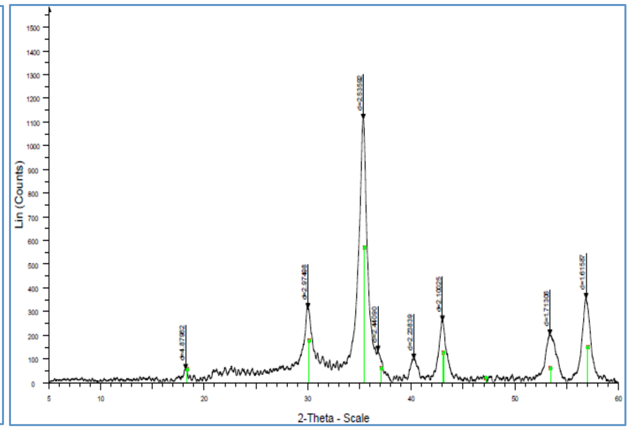


Fig. 1. *ICP-OES of "before and after" treatment with iron oxide.* Results show that the introduction of magnetite nanoparticles cause a sharp drop in the concentration of arsenic present in PAD leachates (here approximately 10ppm to 0.03 ppm).

Fig. 2. *XRD of unknown iron phase via* in situ *synthesis protocol.* Results of XRD show that our unknown product is magnetite, a safe compound that occurs naturally in many parts of the world. This proves to be especially beneficial since arsenic naturally occurs bound to these minerals.