Catalysis plays a significant role in many aspects of everyday life, including but not limited to energy processing, preparation of bulk and fine chemicals, biocatalysis, and pollution prevention.

Research Approach:
- Obtain tungsten oxide deposited on hematite nanoparticles (WO$_x$/$\alpha$-Fe$_2$O$_3$ nanopowder) from collaborators at Argonne National Laboratory
- Analyze W$_x$ coverage (conformal layer or clusters on hematite surface)
- Look at oxidation state of tungsten as the powder is oxidized and reduced

Methods
1. X-ray Diffraction (XRD)
2. X-ray Photoelectron Spectroscopy (XPS)

Results
- XRD was used to explore possibility of significant phase fraction of WO$_x$ on the hematite surface
- Through Scherrer equation, minimum average crystallite size for AD is 30.3$\pm$1.5nm while OX yields 34.5$\pm$1.9nm

Discussion and Conclusions
- High temperature annealing increases crystallite size
- No visible WO$_x$ observed in XRD
- WO$_x$/$\alpha$-Fe$_2$O$_3$ nanopowder samples experience chemical state change in tungsten when transitioning from AD to OX, but not from OX to RE as was the case in the WO$_x$/$\alpha$-Fe$_2$O$_3$ (0001) single crystal sample
- Different chemistry due to nanoscale samples: defect sites and several faces other than (0001) are present

Future work:
- Study WO$_x$ on different substrates
- Investigate how tungsten and vanadium function together as a 'co-doped' catalyst

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