RX 21-16

1. **Research Title:** Microstructural characterization of functionalized MXene nanomaterials

2. **Individual Sponsor:** List the AFRL research topic sponsor's contact information
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3. **Academic Area/Field and Education Level**
Physics, Chemistry, Materials Science and Engineering, or related fields (MS or PhD level)

4. **Objectives:** The goal of this project is to determine the role of various processing parameters on the microstructural features of MXene nanolaminates that have been functionalized with inorganic and organic compounds in solution. We seek to measure the effects of these reactions on the size, interlayer spacing, abundance of various surface terminations, and crystallographic defects in the MXenes. The resulting understanding will impact the optimal processing of these materials for a variety of aerospace applications.

5. **Description:** MXenes are a family of atomically layered 2D nanomaterials consisting of transition metal carbides/nitrides in the form $M_{n+1}X_nT_x$ (n=1, 2, or 3) where M is a transition metal, X is a carbon or nitrogen, and T_x can be any number of native surface groups. MXenes are typically etched from the parent MAX phase in solution, and the etching process gives rise to stacks of 2D flakes with a variety of native surface terminations. For example, the most commonly studied MXene is $Ti_3C_2T_x$, where T_x is oxygen, hydrogen, or fluorine as a result of the HF etching typically used.

   These T_x may be further reacted with a variety of molecules to either replace or alter the surface species, which can have a dramatic effect on the bulk electrical, optical, and mechanical properties of large scale films or composites. For example, an increase in interlayer spacing of only a few nanometers significantly decreases the inter-flake conductivity, which reduces the EMI shielding effectiveness of MXene films. Using advanced electron microscopy techniques, such as electron energy-loss spectroscopy, high resolution imaging, and diffraction, we aim to quantify the effect of various chemical treatments that change the interlayer spacing, degree of surface coverage, and intrinsic electronic states of the individual MXene stacks.

6. **Research Classification/Restrictions:** This research is unclassified.

7. **Eligible Research Institutions:** DAGSI (Wright State University, AFIT, Ohio State University, University of Dayton, Miami University, Ohio University, University of Cincinnati, and University of Akron)

NOTE: Topics submitted to DAGSI must be approved for public release. Need PA Approval #