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AFRL TEAM HOLDS THE CARDS, NEW PATENT, IN BREAKING FROM CONVENTION

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Patent Number(s): US 11,247,915 B1

Wright-Patterson AFB, Ohio –Two scientists working within the Air Force Research Laboratory Materials and Manufacturing Directorate (AFRL/RX) have patented a new process that has upended conventional wisdom. This has blown the door open for a myriad of possibilities for other discoveries in the future.

AFRL/RX Chief Scientist Richard Vaia, Ph.D., and visiting scientist Ali Jawaid, Ph.D., had co-authored several research papers dealing with layered transition metal dichalcogenides (LTMDs). Their research has led to patent #11,247,915 B1: Exfoliated Layered Transition Metal Dichalcogenides.

“LTMDs are a class of two-dimensional inorganic nanocrystals with a unique suite of properties that arises from nanoscale confinement,” Vaia explained. “Vapor deposition techniques prepare high-quality, substrate-supported monolayers that enable novel optical and electronic devices. Alternatively, delamination (exfoliation) of naturally occurring bulk LTMD crystallites in solution allows for integration of these nanolayers into resins, inks, and polymers for industrial manufacturing processes, such as flow coating, printing, spray deposition, and roll-to-roll processing.”

These manufacturing processes are used in a vast range of technologies, including composites, optical films, coatings, lubricants, catalysis, adhesives, energy harvesting devices, energy storage devices, and roll-to-roll printable sensors. A stable dispersion of these nanolayers in solution is required for these processes to work.

“LTMDs provides additional functionality, including optical, electrical, and mechanical to coatings, films, and plastics. LTMDs are a family of materials, and that’s why a common approach to exfoliation is of special interest. If you can develop a generic approach to handling LTMDs, then developers have access to upwards of 40 different compositions, each with a unique suite of properties,” Vaia said.

They patented such a process, called Redox Exfoliation. It provides access to new solution-stable formulations of LTMDs not previously available. This process is creating a new gateway for the development of a broad range of coatings, membranes, and bulk technologies utilizing LTMDs.

Vaia compared the process to a deck of cards. When you synthesize or mine for LTMDs, the particle chunks are like the deck itself. The properties of the chunks are different than that of the individual card. “The whole goal is to pull an individual card off that deck to create 52 layers rather than one particle,” Vaia added.

The ah-ha moment during their research came when Jawaid and Vaia discovered a part of the process for LTMDs, which had been long held to be true, wasn’t exactly accurate.

“We were investigating the exfoliation process and trying to understand the fundamental mechanism underlining why the layers separated. We discovered the explanation in use wasn’t 100 percent correct,” Vaia said. “The common thought was that delamination occurred because the surface energy of the solvent matched the surface energy of the layers. Thus, the increase in surface area between the LTMD and solvent when layers delaminated did not create an energy deficit. We discovered, however, that chemistry at the molybdenum disulfide surface, an archetype LTMD, was occurring with degradation products of the solvent that arose from the aggressive processing conditions. This chemistry and its products are a major driving force for exfoliation and subsequent stability of the layers in solution.”

The Redox Exfoliation process now presents a wide variety of possibilities in creating multifunctional materials for seemingly countless applications. It has resulted in other scientists seeking out these possibilities for both the Department of Defense (DoD) and the commercial sector. It’s something Vaia says could lead to a family of related patents.

“If we want to accelerate technology, it’s best to lead and share fundamental discoveries so others can participate in exploration of impact. This multiplies the innovators who are exploring different commercial products, reduces the over technology risk, and stabilizes industrial supply through a diversity of applications. The game is now on to search the opportunity space between applications and this new family of two-dimensional nanomaterials to see which combinations provide something better than what is commercially in that sector,” he said.

United States Patent Office: #11,247,915 B1

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