REVOLUTIONARY BUILDING MATERIALS

ORAL TESTIMONY

Testimony before the House Committee on Science, Space and Technology, Subcommittee on Energy, hearing on "Building Technologies Research for a Sustainable Future"

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I am a professor of Chemistry, Materials Science and NanoEngineering at Rice University, and part of the Welch Institute for Advanced Materials.

- I have 730 research publications; 234 of those being on the topic of graphene.
- I have over 50 U.S. plus 90 international patents on graphene.
- In the past 6 years alone, my academic research has led to the formation of 14 companies, 8 of those in nanomaterials, and two of them now public companies.

On March 15, 2017, I gave testimony before the Energy and Commerce's Subcommittee on Digital Commerce and Consumer Protection on the topic of graphene and attaining US preeminence. Four years later, I'm here to report that the future has arrived.

What is graphene? Think of it as carbon chicken-wire! That's what it looks like, chicken-wire, in its atomic arrangement, but on the one-atom-thick scale. Graphene is a nontoxic naturally occurring carbon material and its agglomerates are the natural mineral graphite. It is very slow to enter the carbon dioxide cycle and hence it can be considered a terminal carbon sink with near-zero contribution to greenhouse gas emissions.

Graphene is a revolutionary material for building construction, but until recently, affordability and access to sufficient quantities made it only a dream for those applications. In 2018, a graduate student in my laboratory, Duy Luong, working under funding from the Air Force Office of Scientific Research, discovered a process that we call "flash graphene". We immediately filed patents to protect the technology and companies were formed one year later: Universal Matter Inc. and Universal Matter Ltd. The process can take any carbon material—<u>any</u> carbon material—and converted it into graphene in less than one second using only electricity; no water, no solvents, and no additives other than carbon itself. This new graphene manufacturing process will lower the cost by a factor of 10 thereby making it economically viable for use in building materials.

The majority of waste products generated by human beings are carbon-based. If it's not rocks or water, it's probably carbon. We can take coal, petroleum coke, unsorted plastic waste, discarded food, mixed household waste, or any other carbon source and convert it into graphene. Our production rate is doubling every nine weeks, thereby projecting to the hundreds of tons per day scale within three years. With grants from the Department of Energy and the Department of Defense, and in collaborations with the Army Corps of Engineers (ERDC), Argonne National Laboratory, Pacific Northwest National Laboratory, and several large automotive, concrete, asphalt and wood manufacturers, we are developing graphene for concrete, asphalt, steel, aluminum, plastics, polymer-foams, lubricants, rubber, wood, fabric and paint composites.

By adding just 0.1 wt% to cement, we get a 35% enhancement in the compressive strength. It means we could use one third less cement for construction. And since cement and concrete constitute 8% of all worldwide carbon dioxide emissions, that could translate into a remarkable diminution of emissions. Concrete alone is a $30 billion new market opportunity for graphene. 0.5 wt% addition of graphene to asphalt will triple the life of the road. 0.05 wt% of graphene to carbon fiber composites will lower the weight of an aircraft by 20% translating into enormous fuel and carbon dioxide reductions. All made possible by this US invention.

Through Rice University's Carbon Hub, we are developing methods to convert natural gas into hydrogen and graphene with near-zero carbon dioxide emissions. That's clean hydrogen fuel from natural gas.

The next step is to develop entirely new classes of graphene composites that can substitute for the energy intensive 2500-year-old materials that we use today, like concrete and steel, while providing a non-toxic carbon sink for most human waste products.

The take-away from this testimony:

First: Continue to foster support of basic and applied research directed toward the advancement and deployment of new materials. A few years ago, graphene was only viewed as appropriate for ultra-high-end aerospace and device applications, but not anymore. The bipartisan Endless Frontier Act could embody an interesting approach to achieve the requisite research and translational goals.

Second: It remains challenging to go from the lab-bench to the build-site with market profitably. Congress has immense power and influence over tax policy and administrative and regulatory burdens that can make or break our start-up companies.

Third: Streamline the Green-Card process for scientists and engineers that have received their PhDs in the US, so that people like Duy Luong, the Vietnamese graduate student that discovered the flash graphene process in my laboratory, can stay to develop their discoveries in our nation's companies.

Thank you.

James M. Tour, a synthetic organic chemist, received his Bachelor of Science degree in chemistry from Syracuse University, his Ph.D. in synthetic organic and organometallic chemistry from Purdue University, and postdoctoral training in synthetic organic chemistry at the University of Wisconsin and Stanford University.

After spending 11 years on the faculty of the Department of Chemistry and Biochemistry at the University of South Carolina, he joined the Center for Nanoscale Science and Technology at Rice University in 1999 where he is presently the T. T. and W. F. Chao Professor of Chemistry, Professor of Computer Science, and Professor of Materials Science and NanoEngineering.

Tour has about 730 research publications and over 200 patents, with an H-index = 153 and i10 index = 683 with total citations over 110,000.

In 2020, he became a Fellow of the Royal Society of Chemistry and in the same year was awarded the Royal Society of Chemistry's Centenary Prize for innovations in materials chemistry with applications in medicine and nanotechnology. He was inducted into the National Academy of Inventors in 2015. Tour was named among "The 50 Most Influential Scientists in the World Today" by TheBestSchools.org in 2014; listed in "The World's Most Influential Scientific Minds" by Thomson Reuters ScienceWatch.com in 2014; recipient of the Trotter Prize in "Information, Complexity and Inference" in 2014; and was the Lady Davis Visiting Professor, Hebrew University, June, 2014. Tour was named "Scientist of the Year" by R&D Magazine, 2013. He was awarded the George R. Brown Award for Superior Teaching, 2012, Rice University; won the ACS Nano Lectureship Award from the American Chemical Society, 2012; was the Lady Davis Visiting Professor, Hebrew University, June, 2011; and was elected Fellow of the American Association for the Advancement of Science (AAAS), 2009.

Tour was ranked one of the Top 10 chemists in the world over the past decade, by a Thomson Reuters citations per publication index survey, 2009; won the Distinguished Alumni Award, Purdue University, 2009; and the Houston Technology Center's Nanotechnology Award in 2009. He won the Feynman Prize in Experimental Nanotechnology in 2008, the NASA Space Act Award in 2008 for his development of carbon nanotube reinforced elastomers, and the Arthur C. Cope Scholar Award from the American Chemical Society for his achievements in organic chemistry in 2007. Tour was the recipient of the George R. Brown Award for Superior Teaching in 2007.

He also won the Small Times magazine's Innovator of the Year Award in 2006, the Nanotech Briefs Nano 50 Innovator Award in 2006, the Alan Berman Research Publication Award, Department of the Navy in 2006, the Southern Chemist of the Year Award from the American Chemical Society in 2005, and The Honda Innovation Award for Nanocars in 2005. Tour's paper on Nanocars was the most highly accessed journal article of all American Chemical Society articles in 2005, and it was listed by LiveScience as the second most influential paper in all of science in 2005. Tour has won several other national awards including the National Science Foundation Presidential Young Investigator Award in Polymer Chemistry and the Office of Naval Research Young Investigator Award in Polymer Chemistry.