Chemists reinvent the science and industry of making plastics

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Chemists at the University of Pennsylvania have created a new process for free radical polymerization, the chemical reaction responsible for creating an enormous array of everyday plastic products, from Styrofoam cups to PVC tubing to car parts. Unlike the "traditional" method for living polymerization, which has been around for more than 50 years, this method takes place at room temperature, uses less metal catalyst to drive the reaction and requires a very short reaction time.

"We have basically re-written the equation of how the polymerization process can work, which can have a direct impact on the cost of the reaction and the types of materials that we can create." said Virgil Percec, a professor in Penn's Department of Chemistry. "Polymerization is a billion-dollar-a-year industry, and the applications for the technology are enormous, ranging from medicine to coatings, from moldable forms of rubber to electronics and even complex organic synthesis, all via these radical reactions."

This new technique, called Single Electron Transfer-Living Radical Polymerization, also offers chemists greater control over the molecular architecture of the polymers they create and allows them to use materials that did not work with the traditional process. The mechanism of the synthesis reaction works so well that there is very little worry about undesirable side reactions, and the resulting polymers do not need to be purified to remove the catalyst. Their findings are presented in the *Journal of the American Chemical Society*, available online now.

"The SET-LRP mechanism can allow for a greater control over the three-dimensional structure of the polymers being created," Percec said. "The overall process is not only more efficient, it also provides industrial chemists a new creative tool for building consumer and industrial."

Polymerization links individual molecules, referred to as monomers, together to form synthetic products on a larger-scale. In the chemical reaction to create polymers, chemists use catalysts to decrease the amount of energy it takes to create a shared bond between individual atoms of each monomer. The traditional method, referred to as atom-transfer radical polymerization or metal catalyzed living radical polymerization, demands high temperatures and a great amount of the metal catalyst, in part, because the process depends on the energy it takes to transfer inner-sphere electrons –- which are deep within the cloud of electrons surrounding an atom –- in the act of bonding monomers together.

The new method created by Percec and his colleagues involves the transfer of outer-sphere electrons, which requires much lower activation energy and, therefore, a different catalytic cycle than atom-transfer radical addition. Both the traditional and SET-LRP processes use copper-based catalysts to drive the reaction, but the SET-LRP reaction uses a common, elemental form of copper –- in the form of powder or wire -– in the presence of environmentally friendly solvents, such as water, to move the reaction along. This prevents the build up of excess amounts of copper by-products and reduces the need to continually add more catalyst to keep the reaction going.

"While this might seem like a refinement of the traditional process -– the resulting polymers, in fact, are structurally the same –- this method involves an entirely different approach to the chemical reaction," Percec said.

Source: University of Pennsylvania