Metathesis key in production of pharmaceuticals, plastics

BY ALDEMARO ROMERO
AND MICHAEL J. PANIGOT
SPECIAL TO THE SUN

JONESBORO — This year's Nobel Prize in chemistry was awarded for the discovery and application of a little known but tremendously important chemical reaction — metathesis — and this is how it works.

Organic compounds, chemicals based on the element carbon, are of tremendous importance. Not only are they the basis for life on earth but they are also the ones we use to produce pharmaceuticals, dyes, plastics, and other substances in the manufacturing industry. What makes these compounds so vital is the great ability of the carbon atom to form strong bonds not only with other carbon atoms but also with hydrogen, oxygen, halides such as chlorine, and sulfur. Because those bonds can be single, double and even triple, they can form chains of molecules with branched structures and rings of different forms and sizes.

This gives these molecules a tremendous versatility and that is one of the reasons life is based on organic compounds.

However, carbon compounds can also be produced in the laboratory through a process called organic synthesis. A key chemical reaction in which the bonds between different atoms are broken and new ones are formed is called metathesis, a word that literally means "change places." This process was discovered almost by accident in the 1950's.

In olefin metathesis (olefin is another name for alkene, a compound containing a carbon-carbon double bond), the double-bonding atom groups will change places with one another. In this way one can produce new substances just by changing the way atoms are bound. A key component for this reaction is a catalyst, that is, a chemical that makes possible the reaction by increasing its rate and reducing the amount of energy that is necessary for the reaction to take place while the catalyst itself is left unchanged by the reaction itself so it can be used again and again. Enzymes, for example, act as catalysts.

The three winners of the 2005 Nobel Prize in Chemistry played a major role in understanding and applying metathesis as a chemical reaction. Yves Chauvin, of the French Petroleum Institute, discovered in 1971 how metathesis reactions function and what types of metal compound act as catalysts in the reactions. With the "recipe" now in hand, Richard R. Schrock of the Massachusetts Institute of Technology and Robert H. Grubbs of the California Institute of Technology were able to produce in the early 1990's an efficient metal-compound catalyst for metathesis.

'Today metathesis reactions are used daily in the chemical industry.'

Aldemaro Romero and Michael J. Panigot
ASU professors

Today metathesis reactions are used daily in the chemical industry for the production of pharmaceuticals and plastics. With this method the chemical reactions developed by the Nobel laureates allow for a simpler process in terms of the number of reactions required, fewer chemicals needed and fewer wastes produced, safer procedures because the reactions can take place in air at normal temperatures and pressures, and environmentally friendlier because it uses harmless solvents and produces lesser amounts of hazardous by-products.

Because of this, many hope that further understanding and development of this process will lead to what has been labeled as "green chemistry," that is, chemical procedures that are harmless to humans and the environment, which is of great importance anywhere from relatively small teaching labs in schools to the large operations of the chemical industry.

For more information contact the ASU Dept. of Biological Sciences at biology@astate.edu.

Dr. Romero is chairman and professor of biology and Dr. Panigot is interim chairman and associate professor of chemistry at Arkansas State University.