Organic Synthesis and Catalysis

Shun-Ichi Murahashi
Department of Applied Chemistry, Okayama University of Science
Ridaicho 1-1, Okayama 700-00

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The current development of organic synthesis and its extensions to new topics are extremely active, although this is one of the oldest areas of science. The reasons behind the high level of activity lie in the creative nature of the endeavor, and its central position among the sciences. In addition, the field is fundamental to our lives. It has been possible for organic synthesis to continue advancing at a rapid pace for so long, because of its foundation on the basic principles and theories of chemistry, in combination with its constant contact with new and different fields, from which it incorporates fresh aspects and uses them in new, creative areas. This pattern is unlikely to change in the future. However, we now know that environmental conditions must be seriously evaluated, when organic synthesis is being undertaken. The movement in favor of so-called green chemistry, or environmentally benign chemistry, which is focused on processes and products that reduce or eliminate the use and generation of hazardous substances, is worthy of careful consideration. This movement has encouraged industries and academics to devise novel technologies and processes that avoid the formation and use of hazardous substances. In the field of organic syntheses, this impetus has inspired chemists to design new compounds that are less toxic but have the same desirable properties as the compounds currently being used; they are devising greener reaction conditions for previously established syntheses (e.g., by replacement of an organic solvent with water); they are developing greener methods of synthesis for existing chemicals (e.g., by finding reactions that use catalysis rather than stoichiometric reagents). In particular, catalysis is extremely important in organic synthesis undertaken with the goal of developing the most economical route to industrial synthesis of a product for which there is a present need. The chemical industry is under increasing pressure to minimize or eliminate waste production in chemical manufacture. Integrated waste management, zero-emission plants, and environmentally friendly processes are now common goals in the chemical industry. The need for waste reduction is readily appreciated by consideration of the amount of waste produced per kilogram of product, an idea suggested by R. Sheldon, and also called the E factor. In this context, waste is defined as everything produced in the overall process other than the desired product. The keys to waste minimization in organic synthesis are regio-, chemo-, and stereoselectivity, but there is another important category of selectivity, which could be called the atom selectivity of atom utilization. Atom utilization is a useful measure of how much waste the alternative routes to a particular product will generate. Waste is predominantly inorganic salts such as sodium chloride. Atom efficiency is calculated by dividing the molecular weight of the desired product by that of the sum total of all substances used in its preparation. Under current circumstances, organic synthesis will have more precision and elegance if organic synthetic chemists rise to the challenge and more seriously consider catalysis. Organic synthesis is an exciting and powerful key science that present manifold challenges to young scientists.