Unit 6

Green Chemistry

Case Studies

1. Green synthesis methods with green reagents and green solvents.

a) In pharmaceutical industry:

1) **Ibuprofen** is one of the products used in large quantities for making pharmaceutical drugs, in particular various kinds of analgesics (pan killers). The traditional commercial synthesis of ibuprofen was developed by the *Boots company of England* in 1960s.It was 6 step process with atom economy of 40%. Later the *BHS company* developed a new greener synthesis of ibuprofen that consists of 3 steps and atom economy of 77% was achieved. This is the best example of enhanced atom economy and reduction in excessive usage of material which prevents the generation of toxic waste at each step.

2) A drug for treating high cholesterol, **Zocor** (simvastatin), traditionally used a multistep method involving large amounts of hazardous reagents that produced a large amount of toxic waste. A new method for synthesizing the drug uses an engineered enzyme and a low-cost feedstock that was optimized by *Codexis*, a biocatalysis company. Codexis worked with Merck to develop a new catalyst and a greener route for synthesizing sitagliptin, the active ingredient in Januvia™, a treatment for type 2 diabetes. This collaboration led to an enzymatic process that reduces waste, improves yield and safety, and eliminates the need for a metal catalyst

3)In dye Industry: A recent example of a green solvent that is now in commercial use is in fabric dyeing. Traditional dyeing also requires a lot of water—about 7 gallons to dye a T-shirt—and was energy intensive because the dyed material must be dried. Dutch start-up firm *DyeCoo Textile Systems* recently invented an industrial-scale, water-free dyeing process and equipment that uses **supercritical carbon dioxide**, which functions like a liquid when under pressure and at slightly elevated temperature.

d) Polymer Industry: *DuPont's* Sorona® polymer, which earned a Presidential Green Chemistry award in 2003, is an example of a bio-based process that is now commercially

available. DuPont developed the process, which uses a genetically engineered microorganism and renewable corn starch instead of petroleum to make cost-competitive textiles. The Sorona® polymer can be used in apparel, carpeting, and packaging. This bio-based method uses less energy, reduces emissions, and employs renewable resources compared to traditional petrochemical processes.

f) Chemical Industry: One of *Dow Chemical's* awards is for a green catalyst that reduces the environmental footprint associated with producing propylene oxide, one of the biggest volume industrial chemicals in the world. The Hydrogen Peroxide to Propylene Oxide (HPPO) process produces water as by product which made it eco-friendly and greener pathway of synthesis. It was developed jointly with BASF, serves as a chemical building block for a vast array of products including detergents, polyurethanes, de-icers, food additives, and personal care items. The new process requires lower investment cost, raw material consumption is high and selective nature of catalyst gives high yield. Moreover, it reduces the production of wastewater by as much as 70–80 percent and the use of energy by 35 percent over traditional technologies.