COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH
UNIVERSITY GRANTS COMMISSION

CHEMICAL SCIENCES CODE:01

4.2. Green Chemistry

4.2.1. GREEN CHEMISTRY DEFINITION

The term green chemistry is defined as: **The invention, design and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances.**

While this short definition appears straightforward, it marks a significant departure from the manner in which environmental issues have been considered or ignored in the upfront design of the molecules and molecular transformations that are at the heart of the chemical enterprise.

Looking at the definition of green chemistry, the first thing one sees is the concept of invention and design. By requiring that the impacts of chemical products and chemical processes are included as design criteria, the definition of green chemistry links hazard considerations to performance criteria.

Another aspect of the definition of green chemistry is found in the phrase "use and generation". Rather than focusing only on those undesirable substances that might be inadvertently produced in a process, green chemistry also includes all substances that are part of the process.

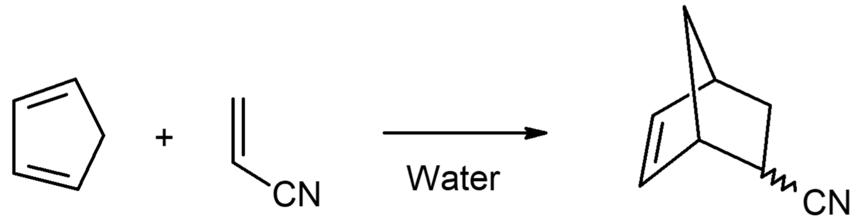
4.2.2. The 12 Principles of Green Chemistry

a) It is better to **prevent waste** than to treat or clean up waste after it has been created.
b) Synthetic methods should be designed to maximize the **incorporation of all materials used** in the process into the final product.
c) Wherever practicable, **synthetic methods** should be designed to use and generate substances that possess **little or no toxicity** to human health and the environment.
d) **Chemical products** should be designed to effect their desired function while **minimizing their toxicity**.

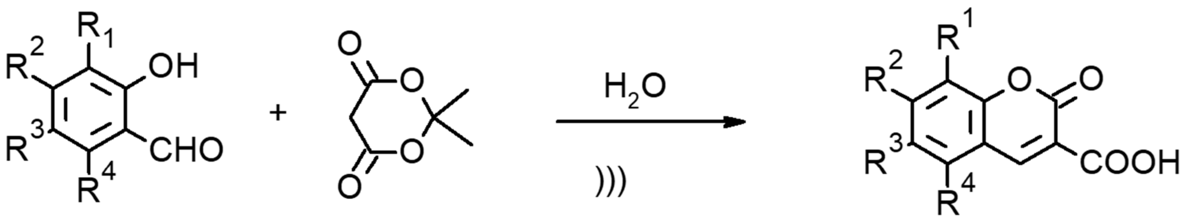
e) The use of **auxiliary substances** (e.g., solvents, separation agents, etc.) should be made **unnecessary** wherever possible and innocuous when used.
f) Energy requirements of **chemical processes** should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at **ambient** temperature and pressure.
g) A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
h) **Unnecessary derivatization** (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.
i) **Catalytic reagents** (as selective as possible) are superior to stoichiometric reagents.
j) Chemical products should be designed so that at the end of their function they **break down into innocuous degradation products** and do not persist in the environment.
k) Analytical methodologies need to be further developed to allow for **real-time**, in-process monitoring and control **prior** to the formation of hazardous substances.
l) Substances and the form of a substance used in a chemical process should be chosen to **minimize the potential for chemical accidents**, including releases, explosions, and fires.
(P.T. Anastas, M.M. Kirchhoff, *Acc. Chem. Res.* **2002**, *35*, 686 – 694.)

3. Examples of Organic Reactions in Water

❖ Diels Alder Reaction

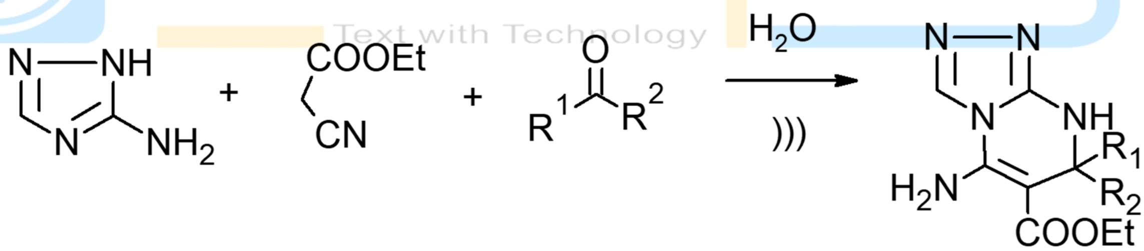


❖ Synthesis of Coumerins



Synthesis of 3-carboxy coumerin

❖ Synthesis of triazolo compounds



❖ Green synthesis of metal nano-particles

$$\text{Au(III)} + \text{o-dihydroxy aromatics} \xrightarrow{H_2O/RT} \text{Au(0) nanoparticles (stabilized)}$$