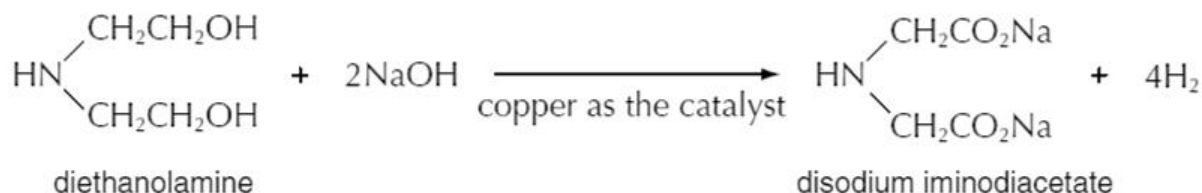


Quiz (Green Chemistry)

- (a) Disodium iminodiacetate (DSIDA) is a key intermediate in the production of a kind of herbicide. Traditionally, DSIDA was produced industrially from ammonia, formaldehyde, hydrogen cyanide and sodium hydroxide as follows:



Recently, a greener industrial process has been developed. It uses diethanolamine (DEA) as the starting material and copper as the catalyst. The production process is as follows:



State and explain THREE green chemistry principles behind the greener process. (Relative atomic masses: C = 12.0, H = 1.0, N = 14.0, O = 16.0, Na = 23.0)

- (b) Polyhydroxyalkanoates (PHAs) are polymers made from renewable raw materials such as sugar and vegetable oils. They can be produced directly in some kinds of bacteria. PHAs can be degraded into harmless products by micro-organisms in a wide variety of aerobic and anaerobic environments. State and explain THREE green chemistry principles behind the use of PHAs.

Suggested Answer

(a) Maximizing atom economy

- For traditional method of DSIDA production:
Mass of atoms in 1 mole of NH_3 = 17.0 g
Mass of atoms in 2 moles of HCHO = 60.0 g
Mass of atoms in 2 moles of HCN = 54.0 g
Mass of atoms in 2 moles of NaOH = 80.0 g
Mass of atoms in 1 mole of $\text{HN}(\text{CH}_2\text{CO}_2\text{Na})_2$ = 177.0 g
Atom economy = $177.0 / (17.0 + 80.0 + 54.0 + 80.0) \times 100\% = 83.9\%$
- For the new method of DSIDA production:
Mass of atoms in 1 mole of $\text{HN}(\text{CH}_2\text{CH}_2\text{OH})_2$ = 105.0 g
Atom economy = $177.0 / (105.0 + 80.0) \times 100\% = 95.7\%$

The new method is greener because the atom economy of the new method (95.7%) is higher than that of the traditional method (83.9%)

Using less hazardous chemical synthesis

- The traditional method used many poisonous chemicals such as ammonia, formaldehyde, hydrogen cyanide and the corrosive sodium hydroxide.
- The new method uses the corrosive sodium hydroxide only. So, the new method uses fewer hazardous chemicals during the synthesis.

Using catalyst

The traditional method did not use any catalyst. On the contrary, the new method uses copper as the catalyst. The use of catalyst can speed up the chemical reaction and get more products in a relatively shorter period of time.

(b) Any THREE of the following:

Using less hazardous chemical synthesis

Sugar and vegetable oils are safe raw materials.

Using renewable raw materials

Sugar and vegetable oils are renewable raw materials.

Reducing derivatives

As they can be produced directly in bacteria, there is no hazardous by-product generated during the synthesis.

Designing degradable chemical products

PHAs can be degraded by micro-organisms in aerobic and anaerobic environments.