# GREEN CHEMISTRY IN INDUSTRIAL PROCESS


Presented by

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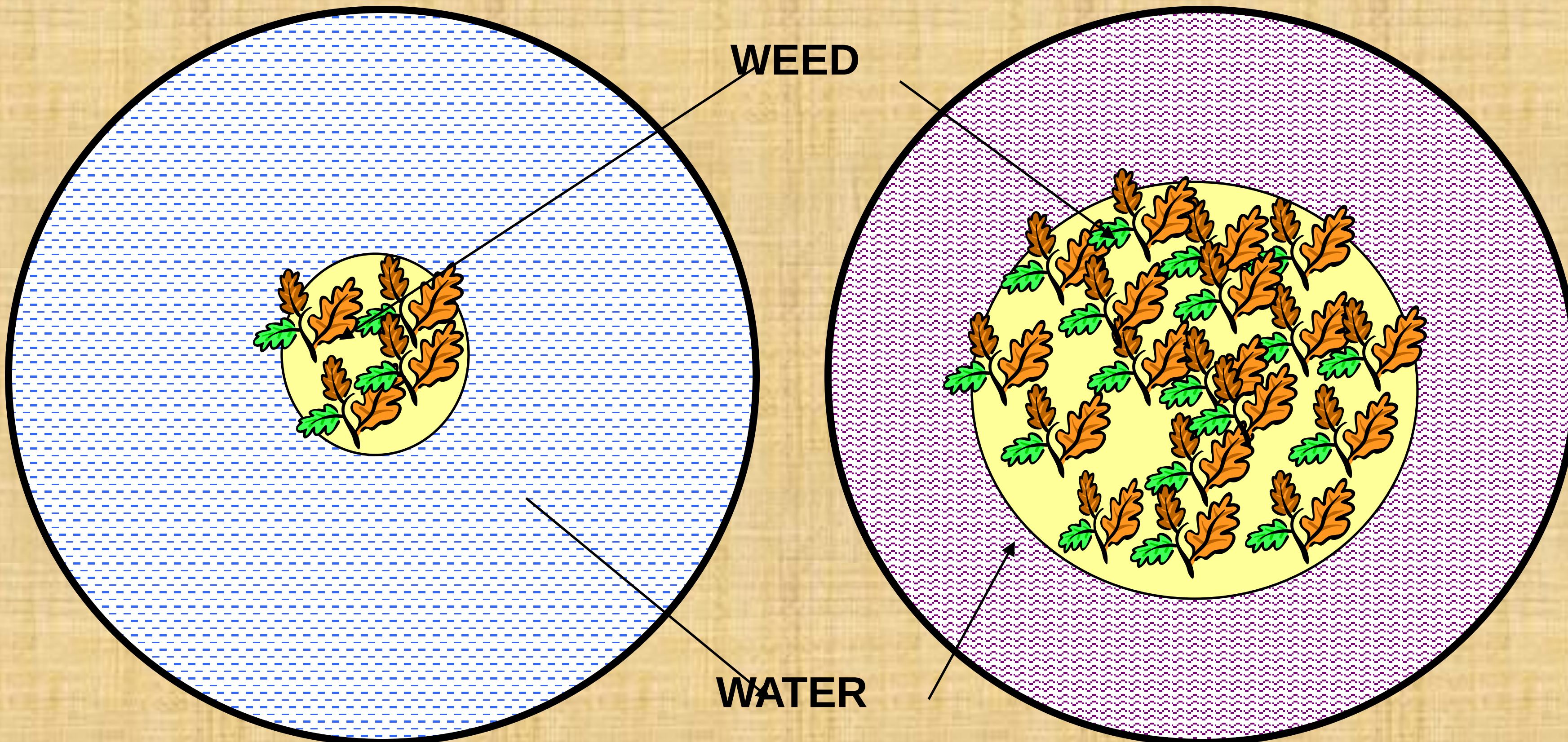
# Contents of Presentation

- What is Green Chemistry?
- Need of the Green Chemistry
- Application of Green Chemistry in Industrial process
- Benefits of Green Chemistry
- Way Forward !!

# POLLUTION STATUS IN INDIA



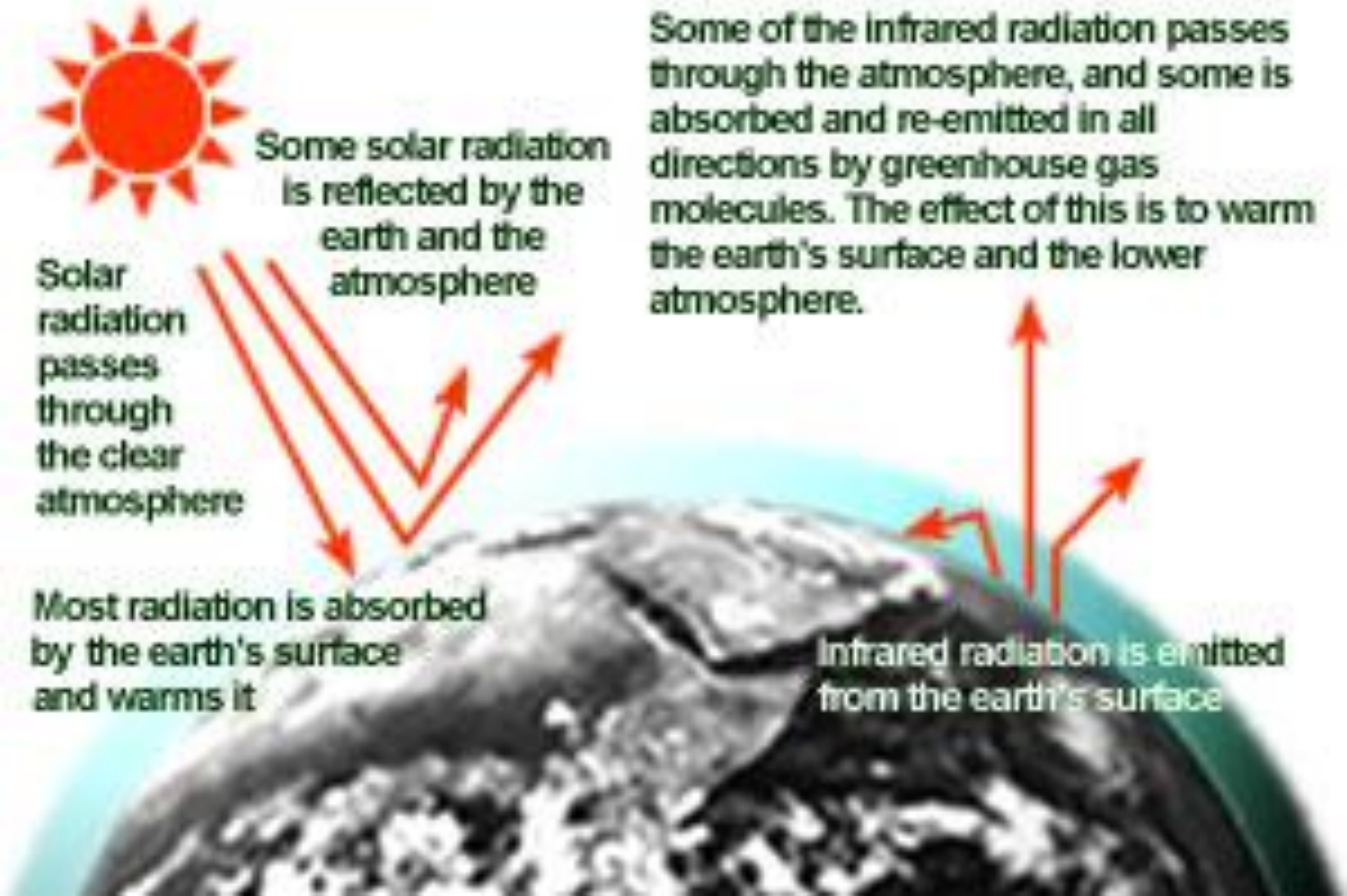

**DAY 1** **DAY 99**

**WHAT WILL HAPPEN ON 99h DAY ?**

# ENVIRONMENTAL LABORAOTRY
# MEDICAL REPORT

| | | |
|---|---|---|
| NAME OF THE PATIENT | : | "EARTH" |
| AGE | : | 3.5 Billion Years |
| DISEASES DIAGNOSED<br>("P" Game Syndrome) | : | Pollution<br>Pesticides<br>Population explosion<br>Politics<br>Poverty<br>POPs |
| NAME OF THE "VIRUS" ATTACKED | : | Human being |
| SYMPTOMS OBSERVED | : | Loss of Biosphere<br>Loss of Natural Resources<br>Increase in Temperature<br>Failure of Monsoon<br>Loss of Human Health |
| LABORATORY ANALYSIS | : | High conc. of pollutants in Soil, Water & Air<br>Large number of PATHOGENIC ORGANISMS |
| TREATMENT REQUIRED | : | Ecological balance<br>Sustainable development<br>Prevention of pollution<br>Need based utilization |
| RECOVERY | : | IN 2047 A.D. (EXPECTED) |

# The Greenhouse Effect



# LEVELS of ATMOSPHERIC $CO_2$ Concentration

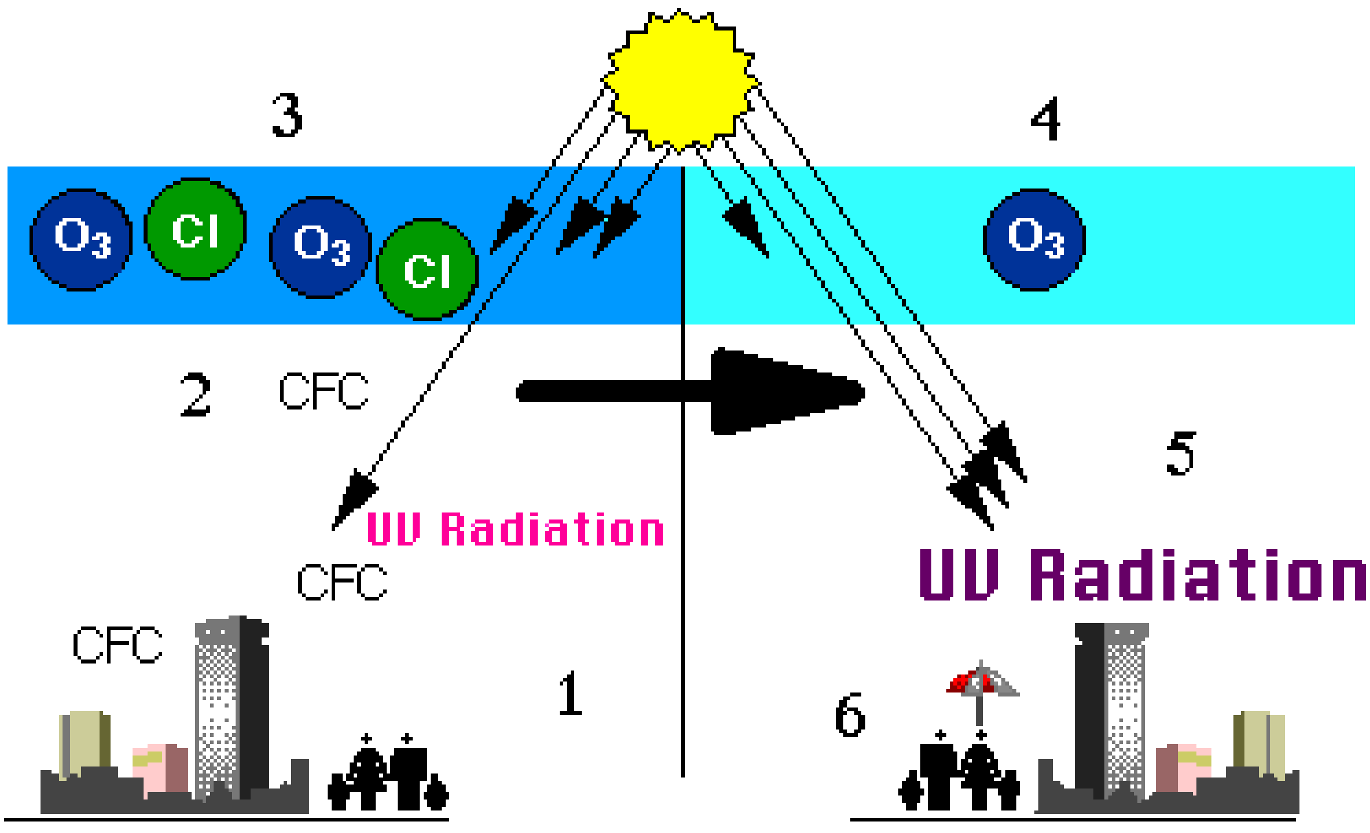
| Year | $CO_2$ level in ppm |
|---|---|
| Pre – industrial Period 1750 A.D. | 276 |
| 2010 | 400 + |

Rate of yearly increase = 1.9 ppm

# AVERAGE CARBON FOOTPRINT PER PERSON FOR DIFFERENT COUNTRIES (in tones of $CO_2$ emitted per year)

| | | |
|---|---|---|
| 1 | US | 20.40 |
| 2 | Canada | 20.00 |
| 3 | Australia | 16.30 |
| 4 | Russia | 10.50 |
| 5 | Greenland | 10.00 |
| 6 | Germany | 9.80 |
| 7 | UK | 9.80 |
| 8 | France | 6.20 |
| 9 | China | 3.84 |
| 10 | India | 1.20 |
| 11 | Pakistan | 0.81 |
| 12 | Bangladesh | 0.25 |
| 13 | Nepal | 0.11 |
| 14 | Afghanistan | 0.03 |

# The Process of Ozone Depletion




1 - CFCs released
2 - CFCs rise into ozone layer
3 - UV releases Cl from CFCs

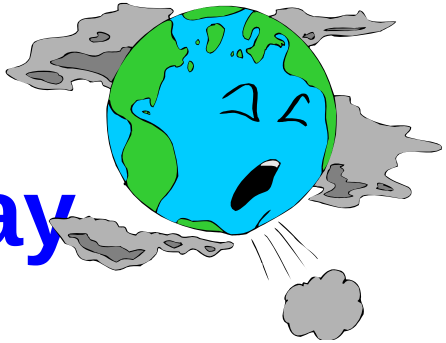
4 - Cl destroys ozone
5 - Depleted ozone -> more UV
6 - More UV -> more skin cancer

# HOW MUCH ……?

We eat - 1 kg food /day

We drink - 6 kg water/day

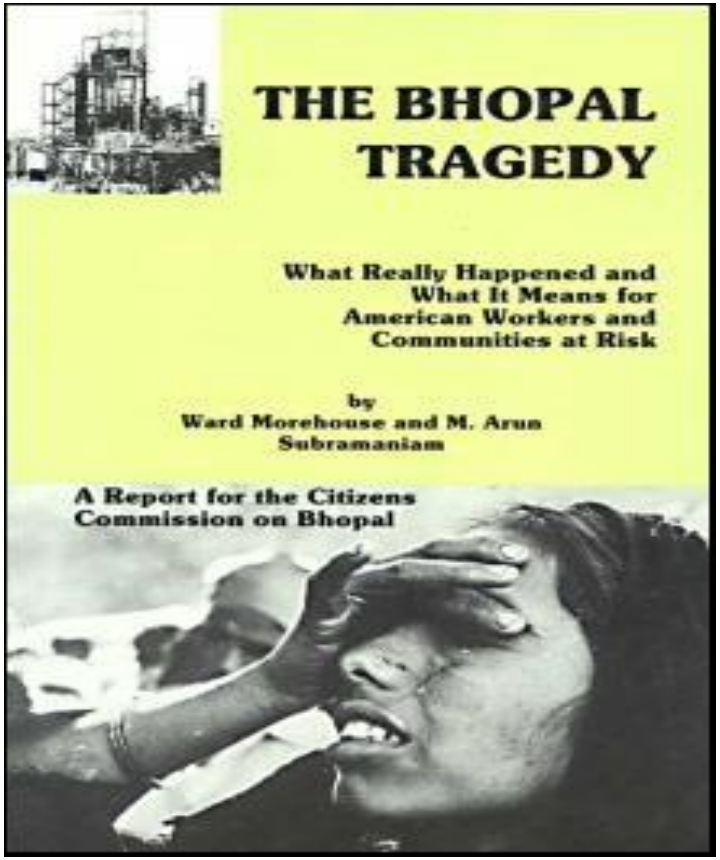
We breath- 12 kg air i.e
13,000 litres/day



# Biological Effects of Pollutants

- Bioconcentration: comparison  between creature's concentration and concentration in environment (i.e. seawater)
- Bioaccumulation: build-up in concentration of something with each step of the food chain
  - Crosses the blood/brain barrier and placenta
  - Eliminated from living tissue very slowly
  - Is contained in fish flesh and is not reduced or removed by cleaning, trimming or cooking
- Biomagnification : **It** refers to the tendency of pollutants to concentrate as they move from one trophic level to the next.

# ENVIRONMENTAL DISASTER EPISODES IN INDIA AND ABROAD



## SOME OF ENVIRONMENTAL DISASTER EPISODE ACROSS GLOBE

- Spring Valley, a neighborhood in Washington, D.C. which was used as a chemical weapons testing ground during World War I.
- Minamata disease – mercury poisoning in Japan (1950s and 1960s)
- Ontario Minamata disease in Canada
- Itai-itai disease, due to cadmium poisoning in Japan
- Love Canal toxic waste site
- Seveso disaster (1976), chemical plant explosion, caused highest known exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in residential populations
- Times Beach, Missouri (1983) the town was completely evacuated due to a dioxin contamination
- Bhopal disaster (December 3, 1984, India), leak of methyl iso-cyanate that took place in 1984 resulted in more than 22,000 deaths.

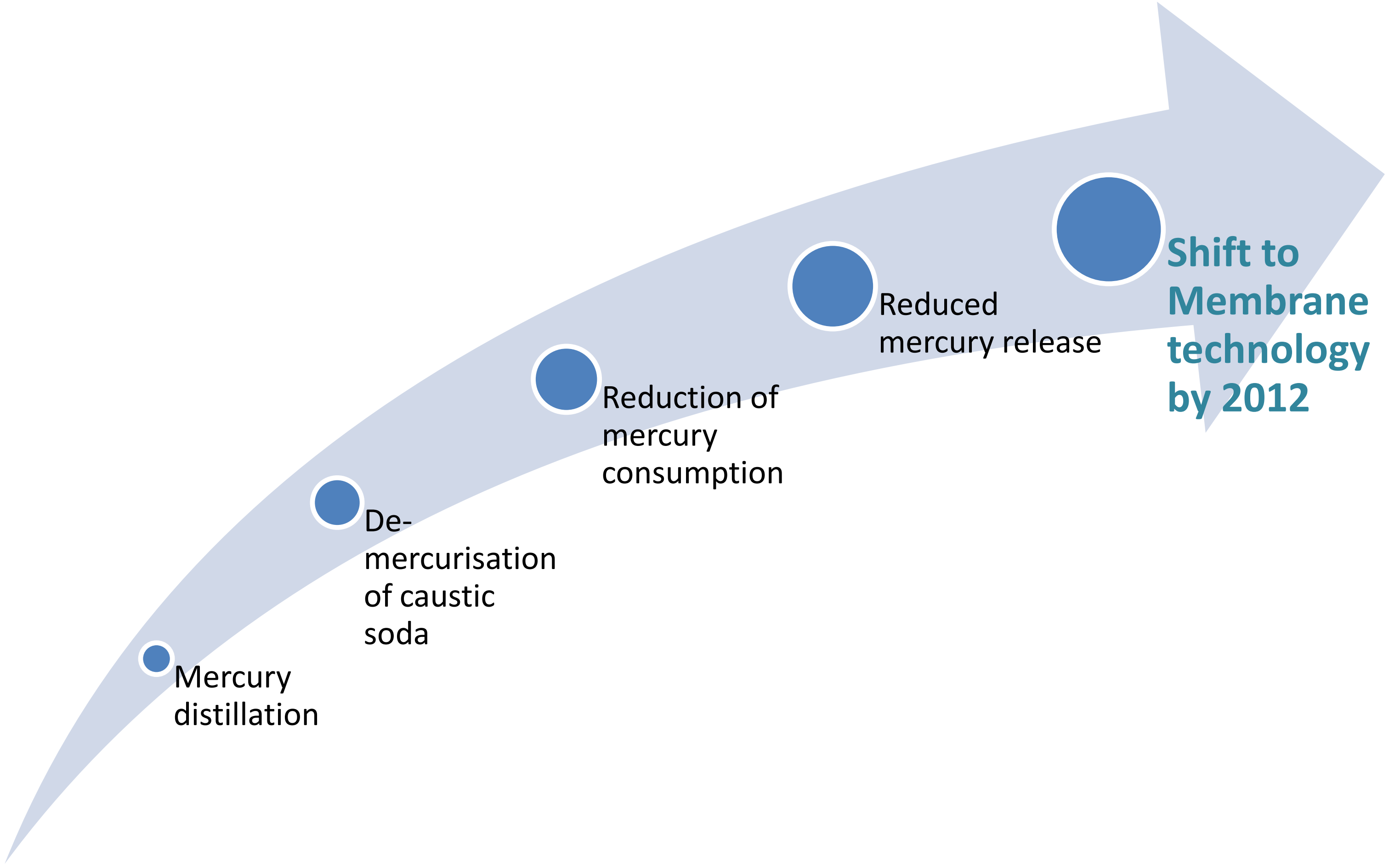
- Sandoz chemical spill into the Rhine river (1986)
- United States Environmental Protection Agency Superfund sites in the United States
- AZF Explosion at a Toulouse chemical factory (2001)
2005 Jilin chemical plant explosions
- The Sydney Tar Ponds and Coke Ovens sites in the city of Sydney, Nova Scotia, Canada, known as the largest toxic waste site in North America.
- Release of lead dust into Esperance Harbour.
- Release of cyanide, heavy metals and acid into the Alamosa River, Colorado from the Summitville mine, causing the death of all aquatic life 17 miles downstream.

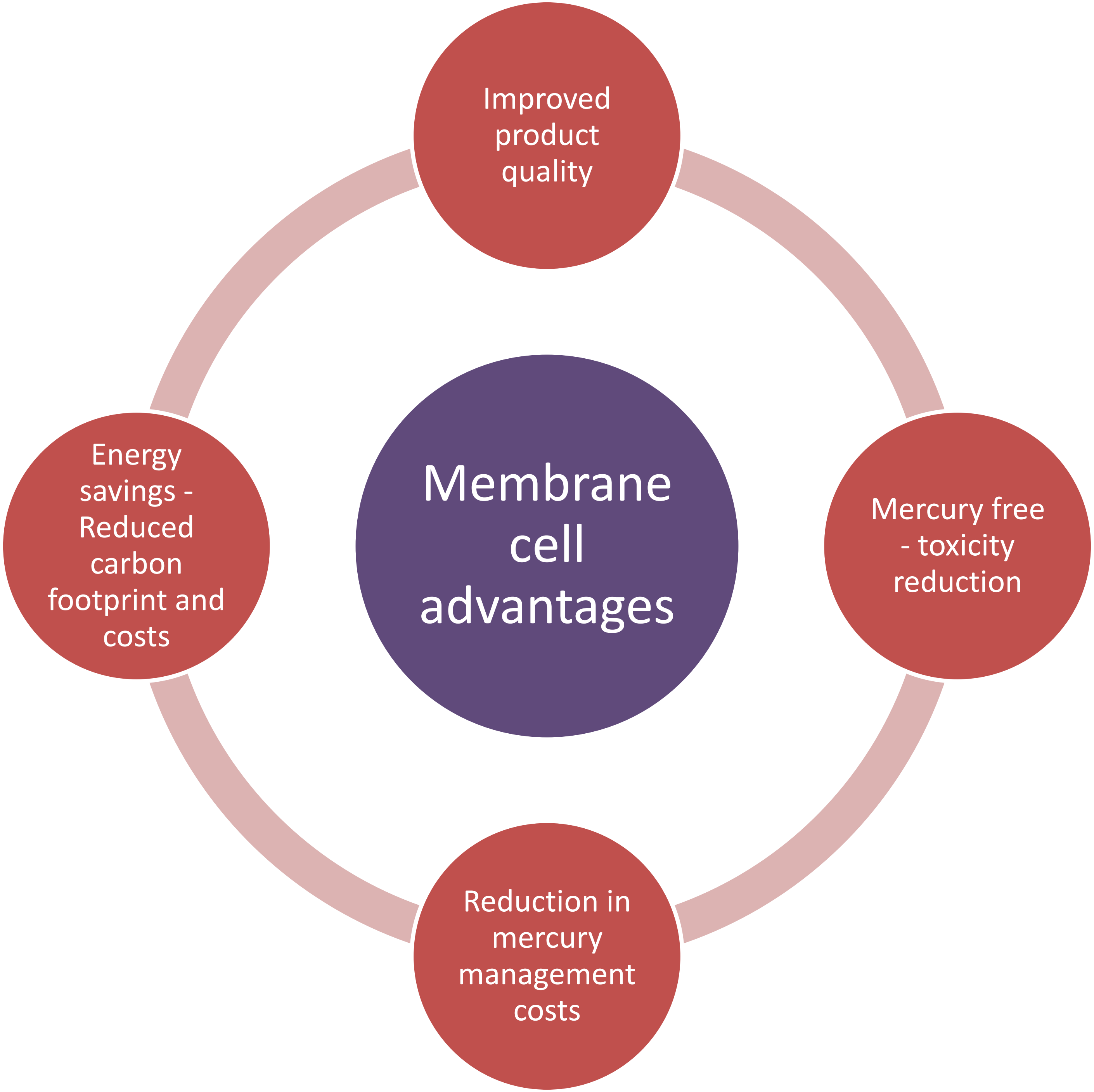
- Release of 20,000 gallons of lethal chemicals (metam sodium, tradename Vapam) into the Upper Sacramento River near Dunsmuir, causing the death of all aquatic life within a 38-mile radius.
- Release of CFCs resulting in ozone depletion
- Release of sulfur dioxide after a fire at the Al-Mishraq plant in Iraq
- The Phillips Disasters
- Health issues on the Aamjiwnaang First Nation due to chemical factories
- Environmental issues with the Three Gorges Dam
- Kingston Fossil Plant coal fly ash slurry spill
- The Great Smog in London in 1952


**Children with congenital Minamata Disease due to intrauterine Methylmercury poisoning. (1986)**

# Charter on Corporate responsibility for Environmental Protection- 2003 ( CREP)

- 17 industrial sectors



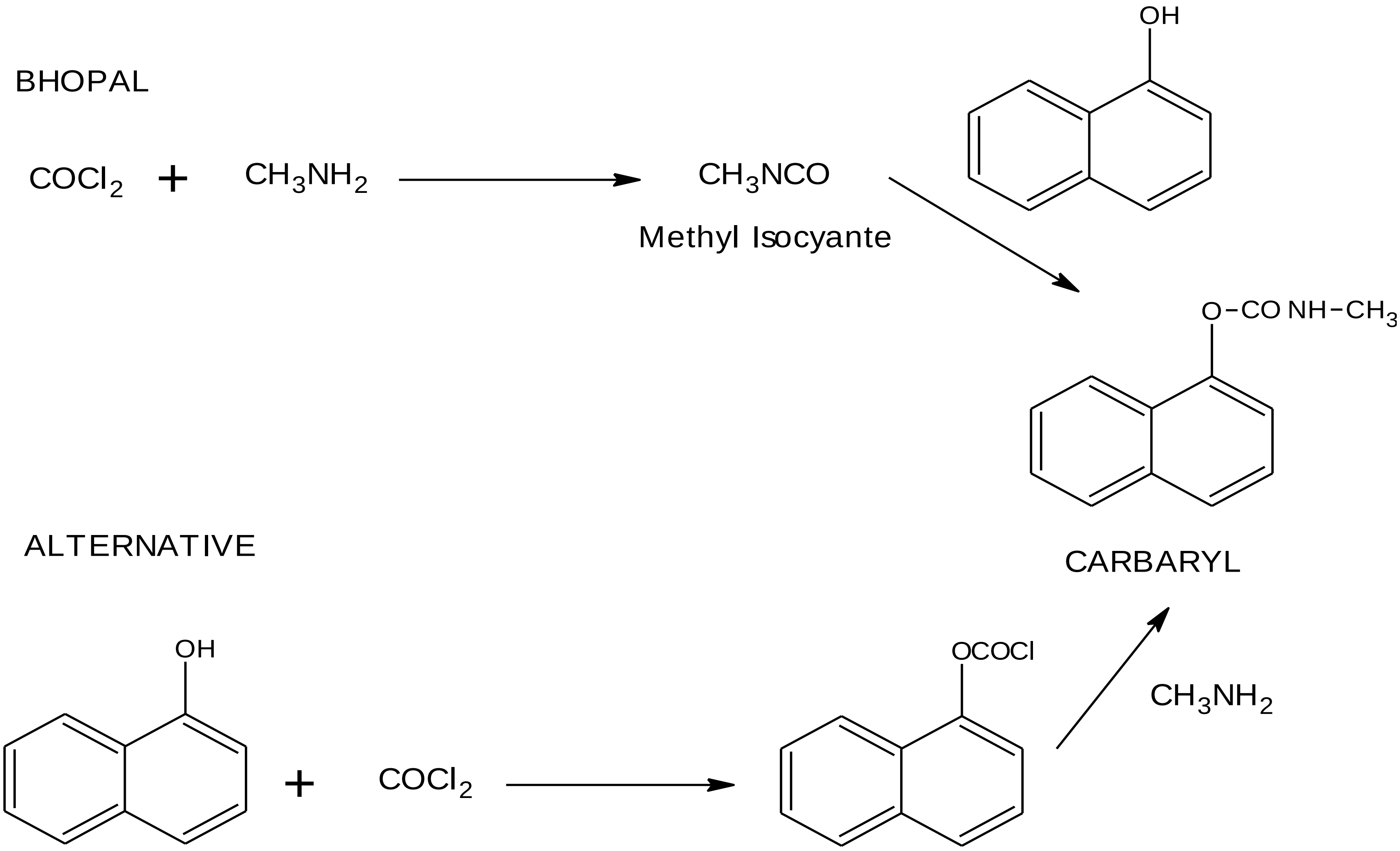

Improved product quality
Energy savings - Reduced carbon footprint and costs
Membrane cell advantages
Mercury free - toxicity reduction
Reduction in mercury management costs

# BHOPAL TRAGEDY

More than three thousand people lost their lives and estimated more than two lacs were seriously injured.

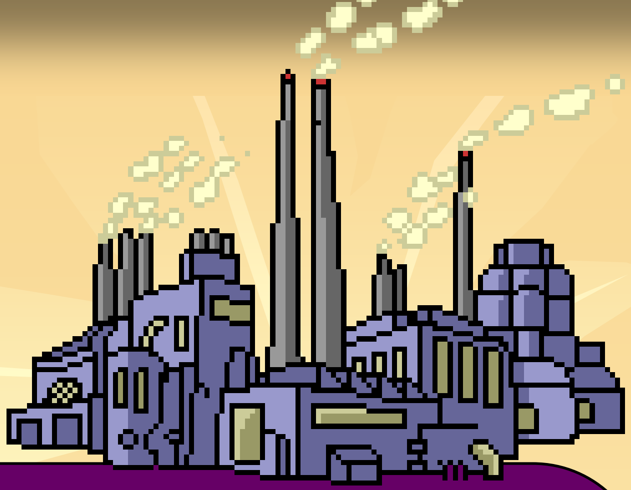
The accident at Bhopal resulted due to ingress of water into large storage tank of methyl isocyanate (MIC). This cause pressure build up. The explosion covered the nearby town with toxic gases. MIC was responsible for Bhopal tragedy and its use could have been avoided by using and alternative synthetic path.

# Alternative to MIC chemical



# Dioxin - major health concerns

- Dioxin are human carcinogen
- Exposure to TCDD increases the risk of cancer at multiple sites, including lung cancer
- Associated with Non-Hodgkin Lymphoma (NHL) or skin cancer. Chloracne is acne like condition develops after first exposure of Dioxin
- Overall increased risk in occupational / accident studies is 40-100%.
- Dioxin act like fat soluble Hormones
- Dioxin are powerful Hormone disrupting chemicals
- Disrupts at least six different hormonal systems ; male and female sex hormones; thyroid hormones; Insulin; gastrin; and glucocorticoid .



# HAZARDOUS & TOXIC
# TRACE ORGANIC POLLUTANTS

# PERSISTENT ORGANIC POLLUTANTS (POPS)

- POPs are compounds that resist degradation and thus remain in the environment for years. POPs- dirty dozen

| | | | |
|---|---|---|---|
| Aldrin, | Chlordane, | DDT, | Dieldrin, |
| Endrin, | Heptachlor, | Hexachlorobenzene, | Mirex, |
| Toxaphene, | PCBs, | Dioxin | Furan |

POPs have the ability to volatilize and travel great distances through the atmosphere to become deposited in remote regions. The chemicals also have the ability to bio-accumulate and bio-magnify, and can bio-concentrate (i.e. become more concentrated) up to 70,000 times their original concentrations.

POPs may continue to poison non-target organisms in the environment and increase risk to humans by disruption in the endocrine, reproductive, and immune systems; cancer; neurobehavioral disorders, infertility and mutagenic effects, although very little is currently known about these chronic effects.

# LIST OF 45 HAPS ( Hazardous Air Pollutants)THAT TARGET HUMAN BODY

**Volatile Organic Compounds**

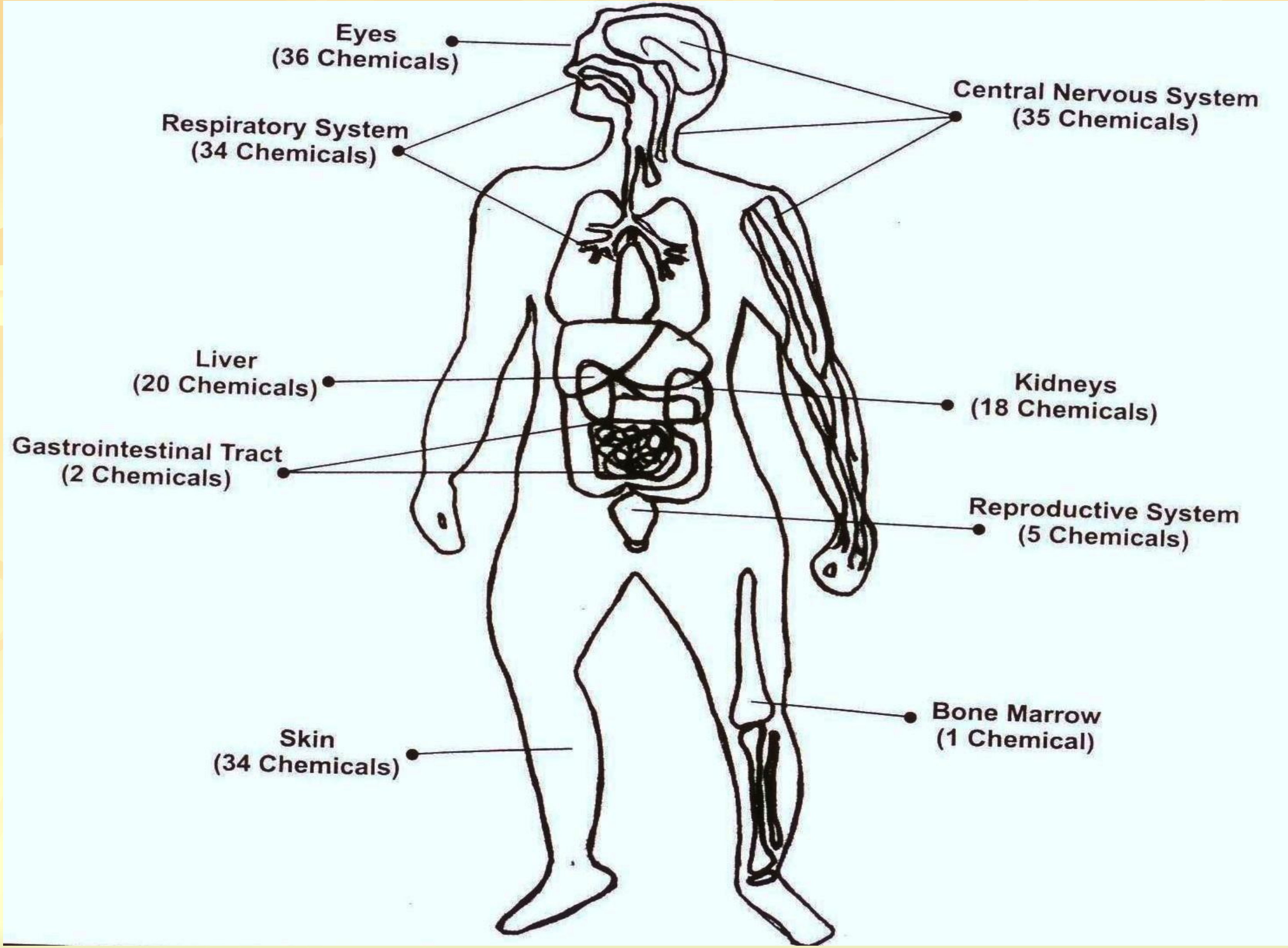
1. Acetone
2. Toluene
3. Chloroform,*
4. Methylene Chloride*
5. Benzene*
6. 2-Butanone
7. Isopropyl Alcohol
8. EthanolA
9. N-Hexane
10. Carbon Tetrachloride*
11. Trichloroethene*
12. Ethyl Benzene
13. m-p, Xylenes
14. Acetonitrile
15. Acrylonitrile*
16. 1,2-Dichloroethane*
17. Vinyl chloride
18. 1-1, Dichloroethane
19. 1,1,2, Trichloroethane*
20. Chlorobenzene
21. O-Xylene
22. 1,2,4, Trimethylbenzene
23. Alpha Pinene
24. d-Limonene
25. 1,3, Butadiene*
26. Acrolien
27. Methyl Tert Butyl Ether
28. Styrene
29. Nonane
30. Chloromethane*
31. N-Butyl Acetate
32. Hexachlorobutadiene*
33. Chloroethane
34. Trichlorfluoromethane
35. 4-Methyl 2-Pentanone
36. Cumeme
37. 1,3,5, Trimethylbenzene
38. Bromomethane*
39. Vinyl Acetate

**Sulphur Compounds**

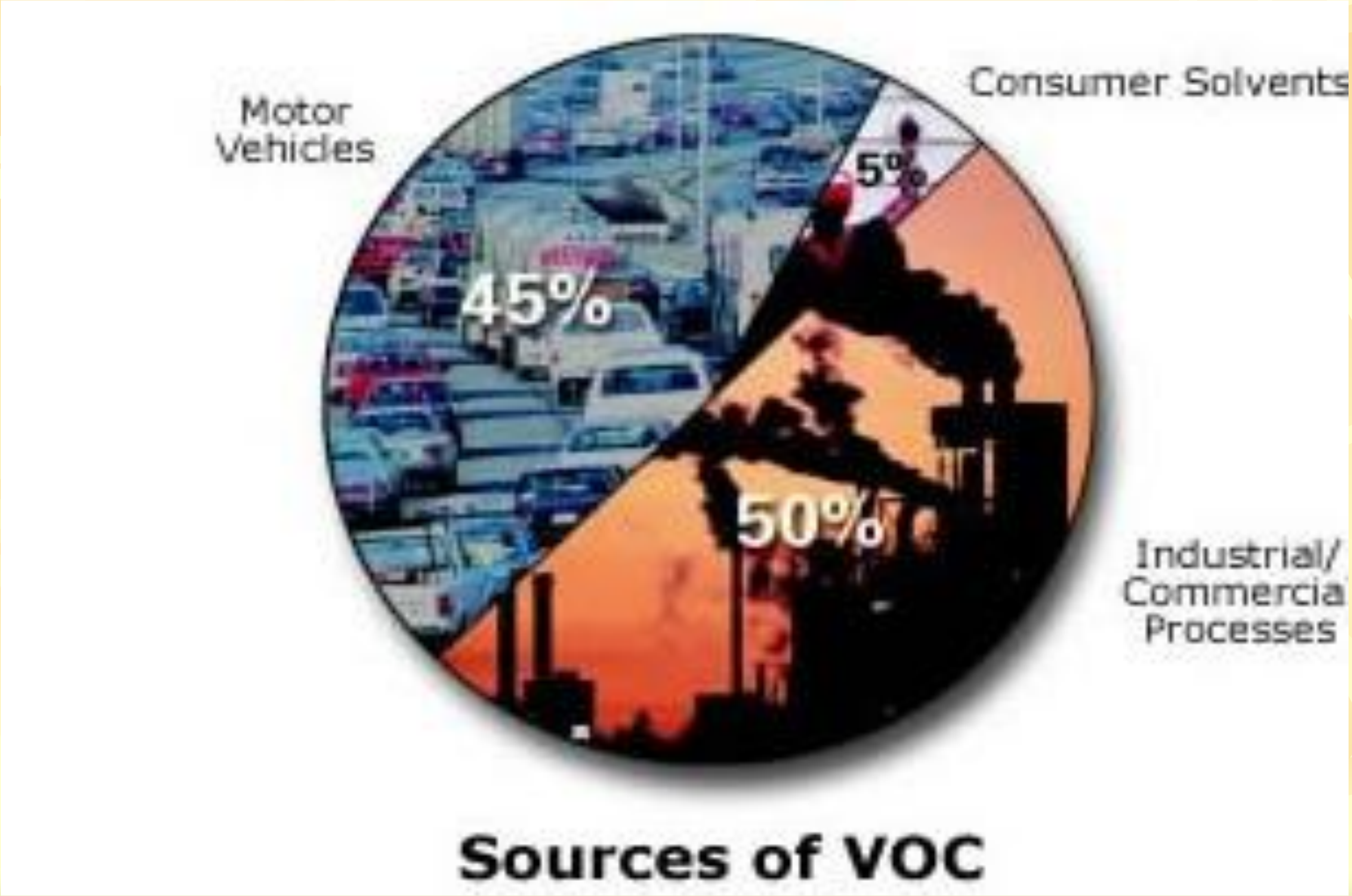
40. Carbon Disulphide
41. Hydrogen Sulphide
42. Methyl Mercaptan
43. Dimethyl Disulphide
44. Dimethyl Sulphide
45. Carbonyl Sulphide

(* known or suspected human or animal carcinogens)

# HAPs THAT TARGET VARIOUS PARTS OF HUMAN BODY



# POTENTIAL GENERATORS OF VOC



# EFFECTS OF VOC

**General Effects**

- VOC are contributors of ozone formation in the presence of sunlight
- Damage the vegetations and materials
- Greenhouse gas – Global warming

**On Human Health**

- Acute effects - Breathlessness, Irritation of eye, nose and skin, Dry throat, Loss of coordination, Headache.
- Chronic effects - Heart attacks, Damage to liver, kidney, Lungs & Central nervous system
- Carcinogenic Effects due to VOCs like Benzene, Formaldehyde, 1,3-Butadiene. Higher exposures to formaldehyde may also cause memory problems and anxiety.

# Dioxin Chemical Health Effects

BEFORE Ukraine President AFTER

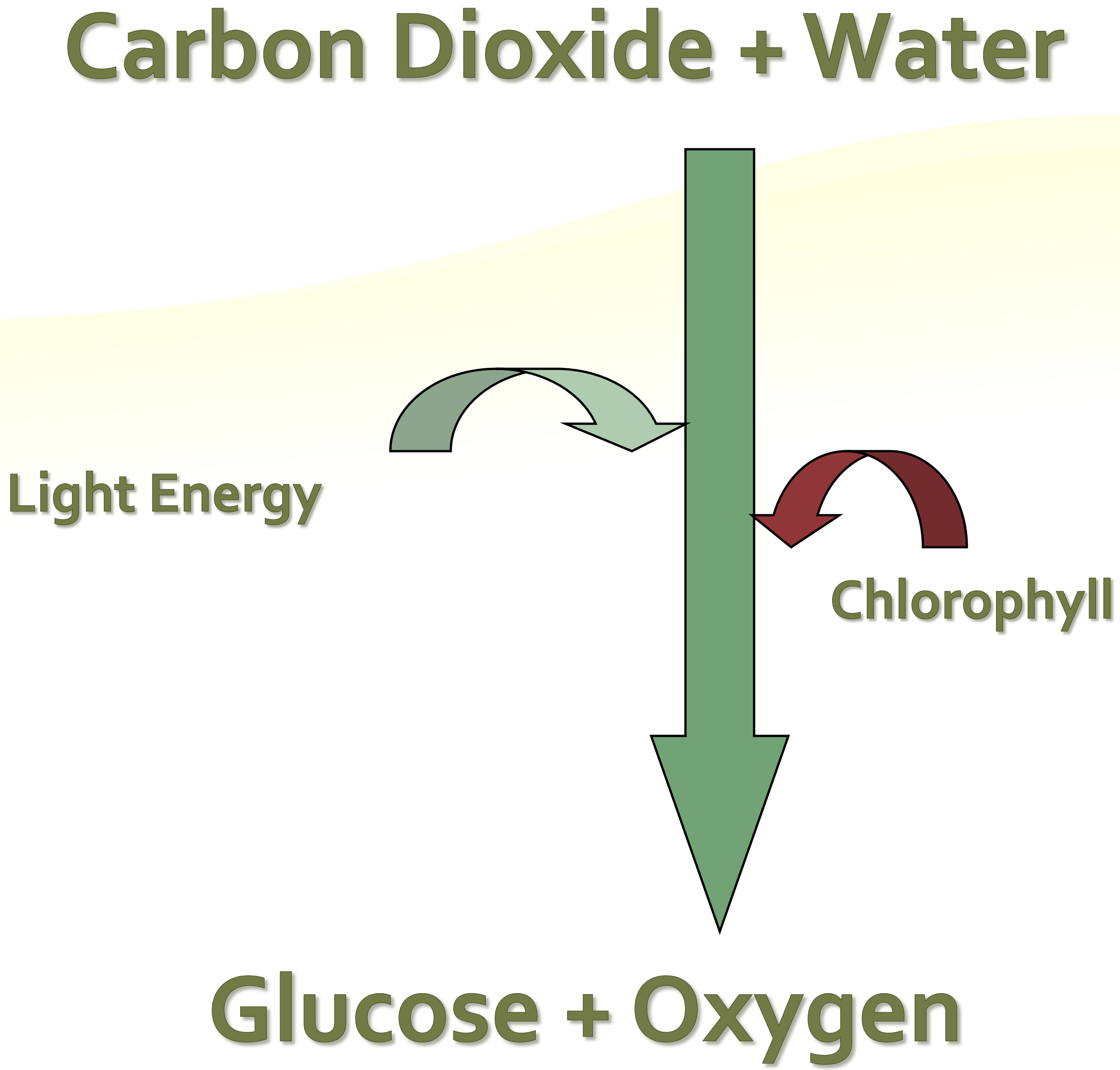
Yushchenko endured dioxin poisoning, likely by political foes, which, along with nearly killing him, left his skin severely disfigured. WILLisms.com

# Health Effects Due to Pollution in India

- **Lead in School Children of Delhi**
  - Earlier (1980's) : 15 - 50 µg/dl (Ref: BARC)
  - Present : 8 -15 µg/dl (Ref: AIIMS)
  - Safe Limit : 10 µg/dl
- **CO in Blood of Exposed Population**
  - CO -Hb : 3 - 5.3 % (Ref: NIOH)
  - Safe Limit : 2%
- **Benzopyrene Level in Ambient Air: Proven Carcinogen**
  - 26 ng/$m^3$ (Delhi) 56 ng/$m^3$ (Mumbai)
  - 21 ng/$m^3$ (Kolkata) (Ref: NEERI)
  - Safe Limit : 10 ng/m3
- **Benzene in Air of Metro Cities**
  - Proved Carcinogen
  - Safe Limit : 1 µg/$m^3$

# GREEN CHEMISTRY

# Green is in Centre : Balancing


Carbon Dioxide + Water
Light Energy
Chlorophyll
Glucose + Oxygen

# PLANT FACTORY

**Plants can manufacture 1000 s of Chemicals of various compounds at Normal Atmospheric Pressure , Temperature**

**But we Can’t Why ?**

# “Green “ –

widely use terminology in…

Products
Companies
Buildings
Campuses
Materials, etc

# What is Green Chemistry ?

"The design of chemical processes, products and technologies that reduces or eliminates the use and generation of hazardous substances"

- Green chemistry is a mix of organic chemistry, inorganic chemistry, biochemistry and analytical chemistry.

- Its main goal is to develop methods that help **avoid dangerous chemical waste.**

# GREEN CHEMISTRY

- ***Green Chemistry,* or sustainable/environmentally benign chemistry is the design of chemical products and processes that reduce of eliminate the use and generation of hazardous substances**

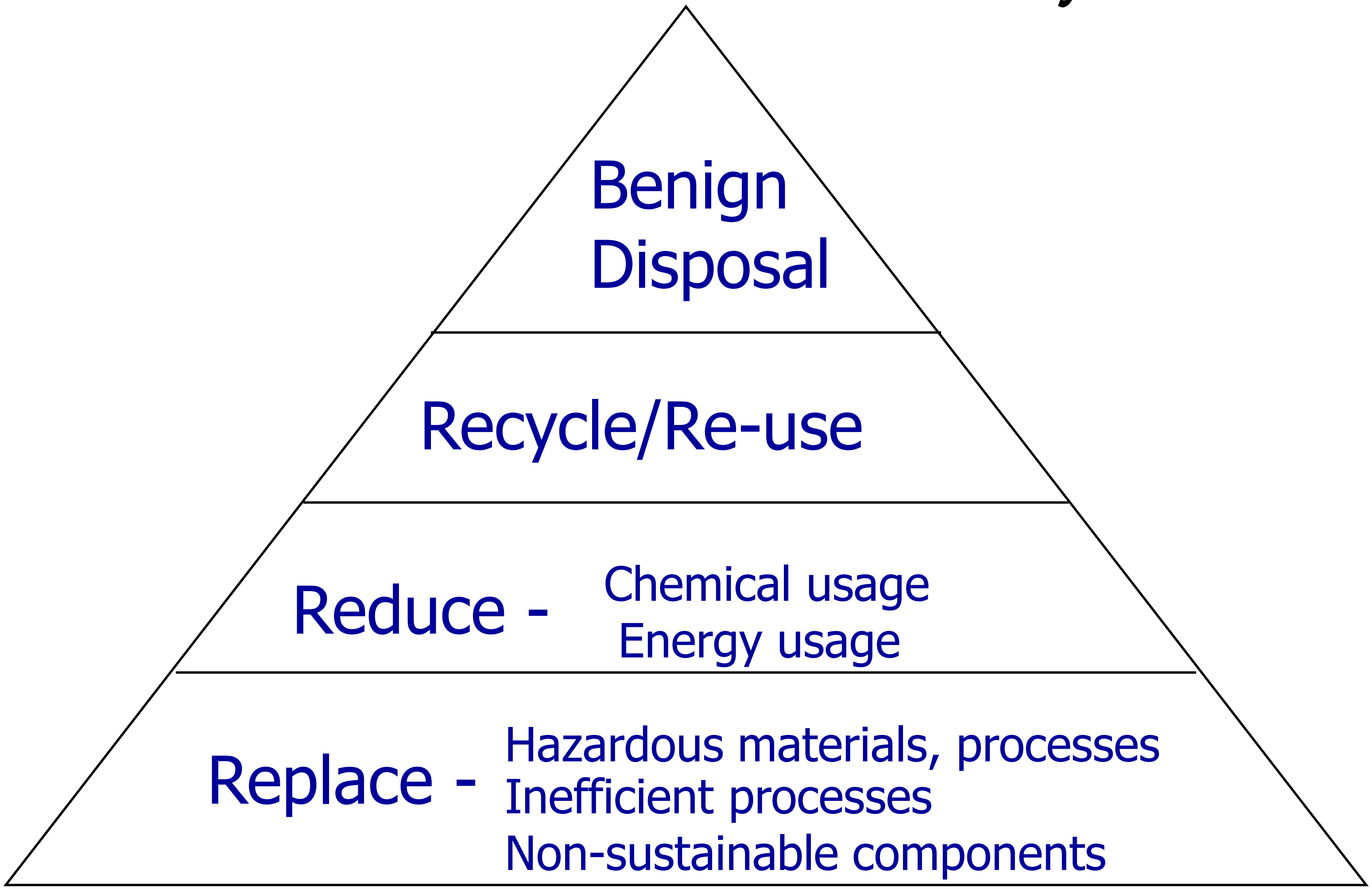
**GC minimize:**

– waste, energy use , resource use (maximize efficiency)

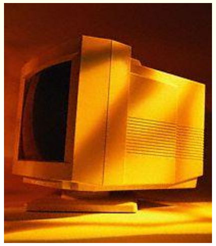
- Risk to human health and the environment
- Generation of pollution at the source
- utilize renewable resources

– Transforms existing practices to promote sustainable development

# What is Green Chemistry?



# Benefits of the Chemical Industry



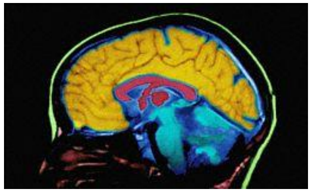








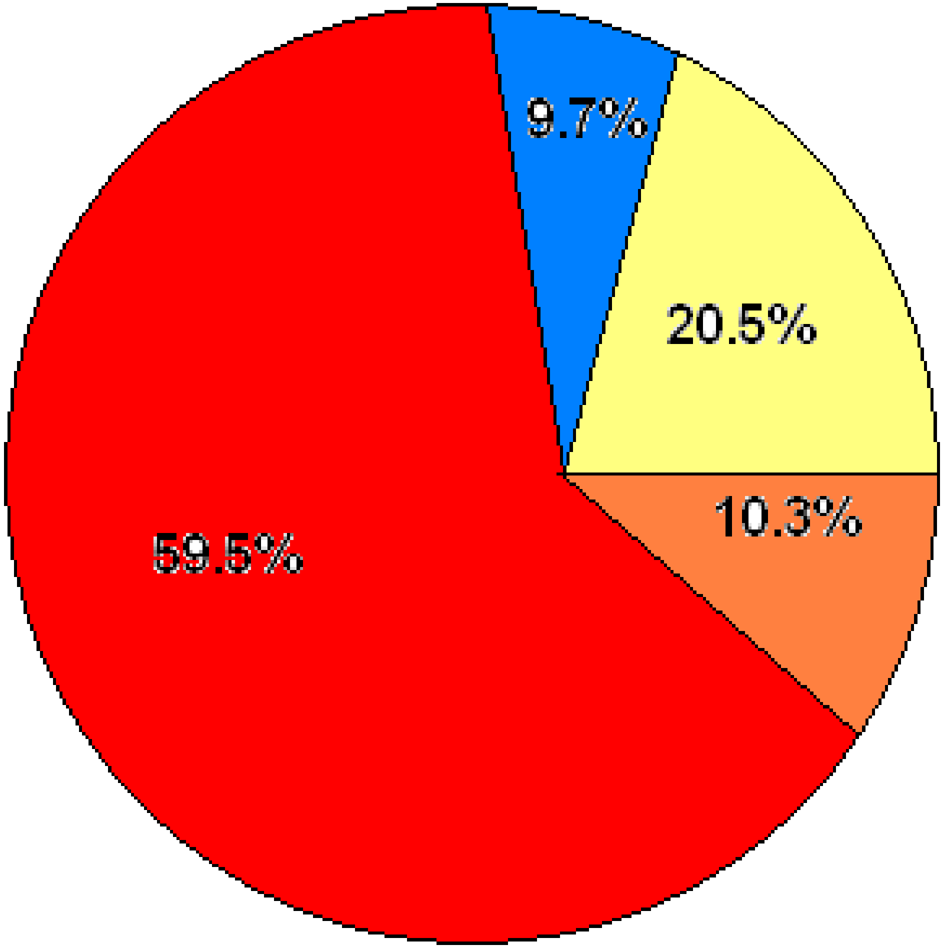




# DEFINATION OF CHEMICAL INDUSTRY




Chemical industry is the most responsible source of pollutants and wastes to the environment. The general perception of the chemical industry is that, it has been responsible for an array of ***environmental and health related problems***.



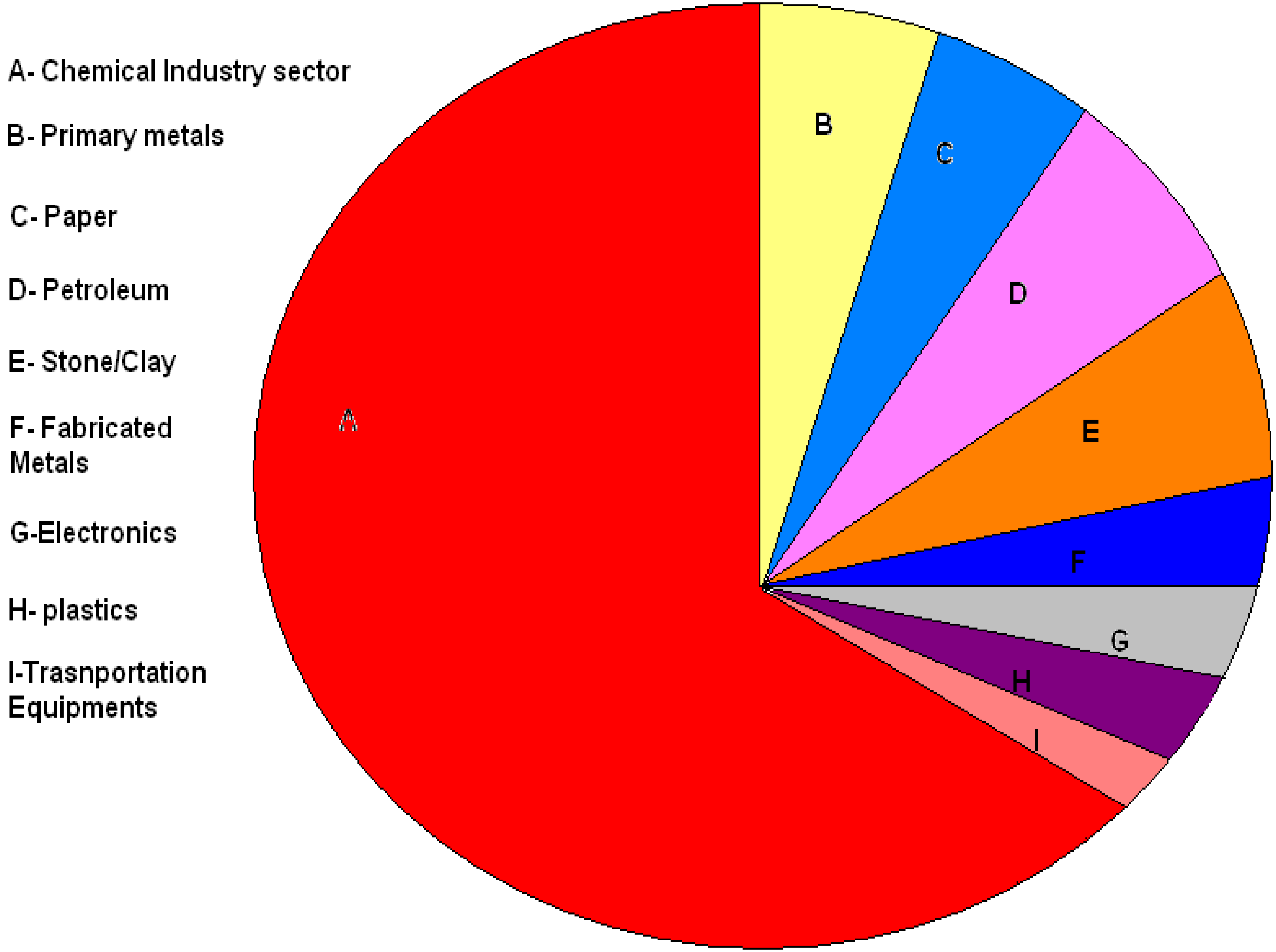

Chemical Release to the environment

59.5% - AIR

20.5% - Underground injection

10.3 - Land

9.7% - Surface Water

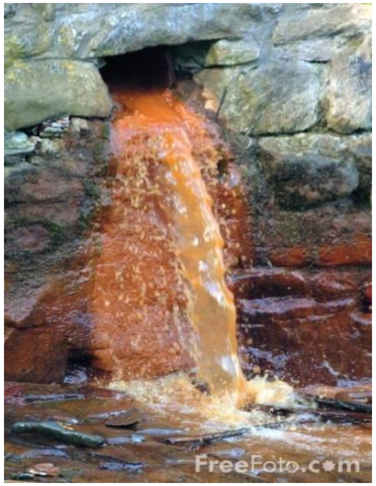



Chemical release by industrail sector in millions of pounds

# Green Chemistry

*Hazardous chemicals*

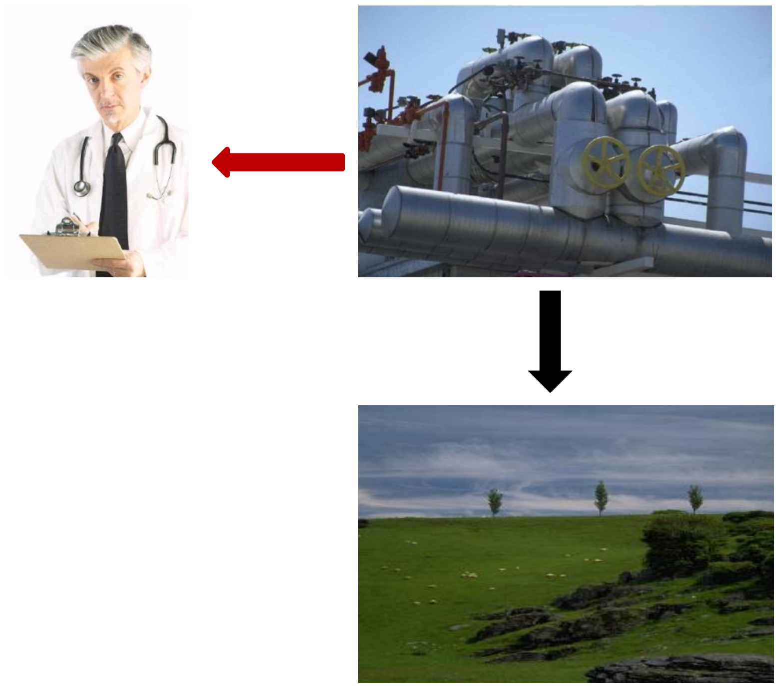
| Chemical products | Chemical by-products | Exhaust gases | *Organic solvents* |
|---|---|---|---|
| Fertilizers, Pesticides | (Chemical wastes) | $CO_2$, $SO_2$, $NO_2$ | Chlorinated solvents |


# Green Chemistry

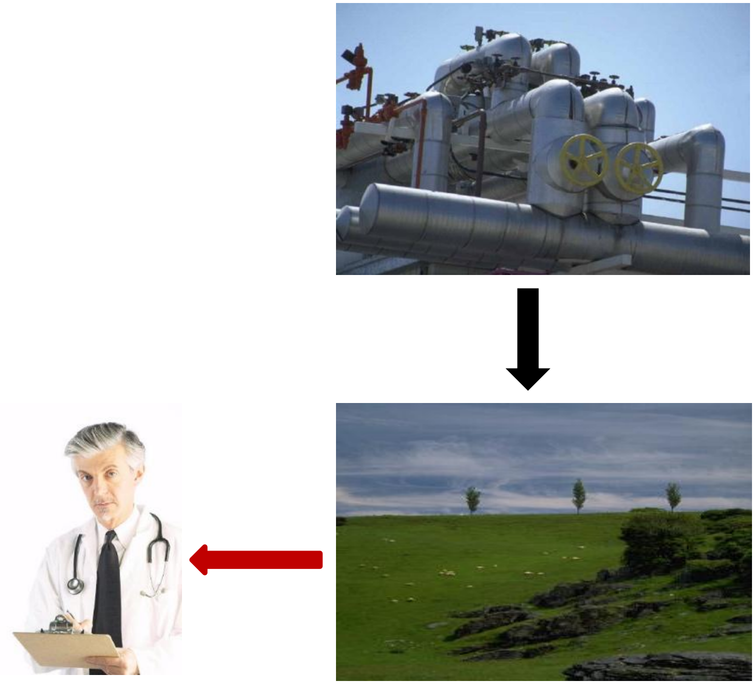
## Green chemistry

<u>Preventing the pollution at its source</u>
With emphasizing on minimizing the hazard, and maximizing the efficiency of any chemical process



## Environmental chemistry

Studying <u>the effect of the pollutants on the environment</u>, and the remediation processes



# The Twelve Principles of GREEN CHEMISTRY (Anastas and Warner 1998)

1. It is better to prevent waste than to treat or clean up waste after it is formed.

2. Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

**3. Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.**

**4. Chemical products should be designed to preserve efficacy of function while reducing toxicity.**

**5. The use of auxiliary substances (e.g. solvents, separation agents, etc.) should be made unnecessary whenever possible and, innocuous when used.**

**6. Energy requirements should recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.**

**7. A raw material feedstock should be renewable rather than depleting whenever technically and economically practical.**

**8. Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible.**

**9. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.**

**10. Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.**

11. Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.

12. Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires.

# ATOM ECONOMY

***"Because an Atom is a Terrible Thing to Waste"***

- How many of the atoms of the reactant are incorporated into the final product and how many are wasted?

# Atom Economy

- One of the key ideas of green chemistry is that of atom economy.
- This considers how much of the reactants in a chemical reaction end up in the final-useful product.
- Ideally all the atoms of the reactants would end up into useful products, no waste at all.

# Reaction between ethyl propionate and methylamine to form N-methyl propionamide and ethanol.

$$CH_3CH_2COOCH_2CH_3 + CH_3NH_2 \text{ -----> } CH_3CH_2CONHCH_3 + C_2H_5OH$$

| | | | |
|---|---|---|---|
| 1 mol | 1 mol | 1 mol | 1 mol |
| 118 g | 31 g | 103 g | 46 g |

- 149 g of. starting materials (118 g + 31 g) yet the mass of the required product 103 g. The rest, 46 g of ethanol, is wasted.
- We have lost 2 atoms of carbon, 6 of hydrogen and one of oxy

$$\% \text{ Atom economy} = \frac{\text{mass of desired product}}{\text{mass of desired products plus waste products}} \text{ X } 100\%$$

$$\text{In the example above, the atom economy} = \frac{103}{149} \text{ X } 100\% = 69.1\%$$

## Reaction type and atom economy

**Chemical reactions are often classified as addition, elimination, substitution and rearrangement.**

### Addition

$$CH_2{=}CH_2 + Br_2 \text{ -------> } CH_2BrCH_2Br$$

28 160 188

$$\text{The atom economy} = \frac{188}{(28+160)} \times 100\% = 100\%$$

Atom economy of all addition reactions is 100%.

# Examples of Green Chemistry

- New syntheses of Ibuprofen.
- Replacing VOCs and chlorinated solvents.
- Liquid Carbon dioxide as a solvent
- Many new pesticides.

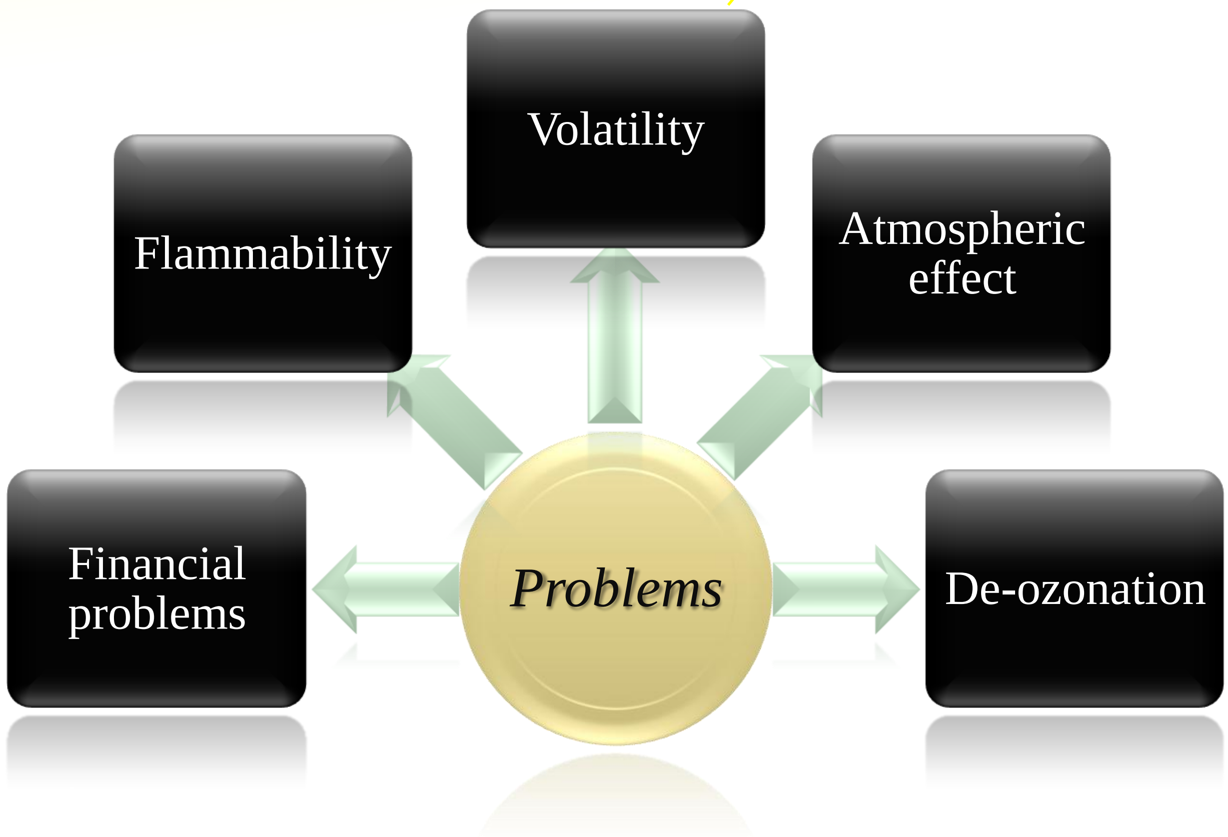
## *Organic solvents:*

❖ Out of the top 10 chemicals disposed of by the chemical industry in the mid-1990s, five were solvents: *methanol, methylethyl ketone, tolouene, hexane and methylene chloride.*

.

- They escape into the environment through evaporation and leakage, threatening the living beings due to ***their high stability and non-biodegredability.***
- They often have complex negative effects on the environment , they have been one of the source of ***ozone depletion, global climate change and smog formation .***

- Dangerous to the workers.
- Working under high pressure, combustion hazard.
- Escape to the atmosphere through evaporation.



# Problems with Traditional solvents

- Direct
  - **Varying toxicity** depending on nature of VOC, exposure method and duration.
    - E.g. DMF (teratogenic), $CHCl_3$ (suspect carcinogen)
  - **Flammability** (fire hazards)
  - **Peroxide formation** (usually ethers)
- Indirect
  - **Ozone depletion**
    - Chlorofluorocarbons (CFC's) now phased out
      - E.g. $CF_3Cl$, lifetime in atmosphere 640 years, GWP 14,000
      - $CCl_4$ – now much more limited use (35yrs, GWP 1400)
  - **Global warming potential** (GWP)
    - E.g. HFC134a ($CH_2FCF_3$) used in refrigerants and air conditioning units, 14yrs, GWP 1300
  - **Environmental persistence**
- Use of less volatile solvents may improve environment as long as they do not lead to problems elsewhere.

# Green Solvents Defination.

- The commonly used solvents like Benzene. Toluene, Methylene Chloride etc. For Organic Synthesis particularly in Industrial Production are known to cause health and environmental problems.
- In view of this, search for alternatives to the damaging solvents is of highest priority.This is particulary important as solvents are used in huge amounts in Industrial production and these are mostly volatile liquids which are difficult to store.

# Green Solvent

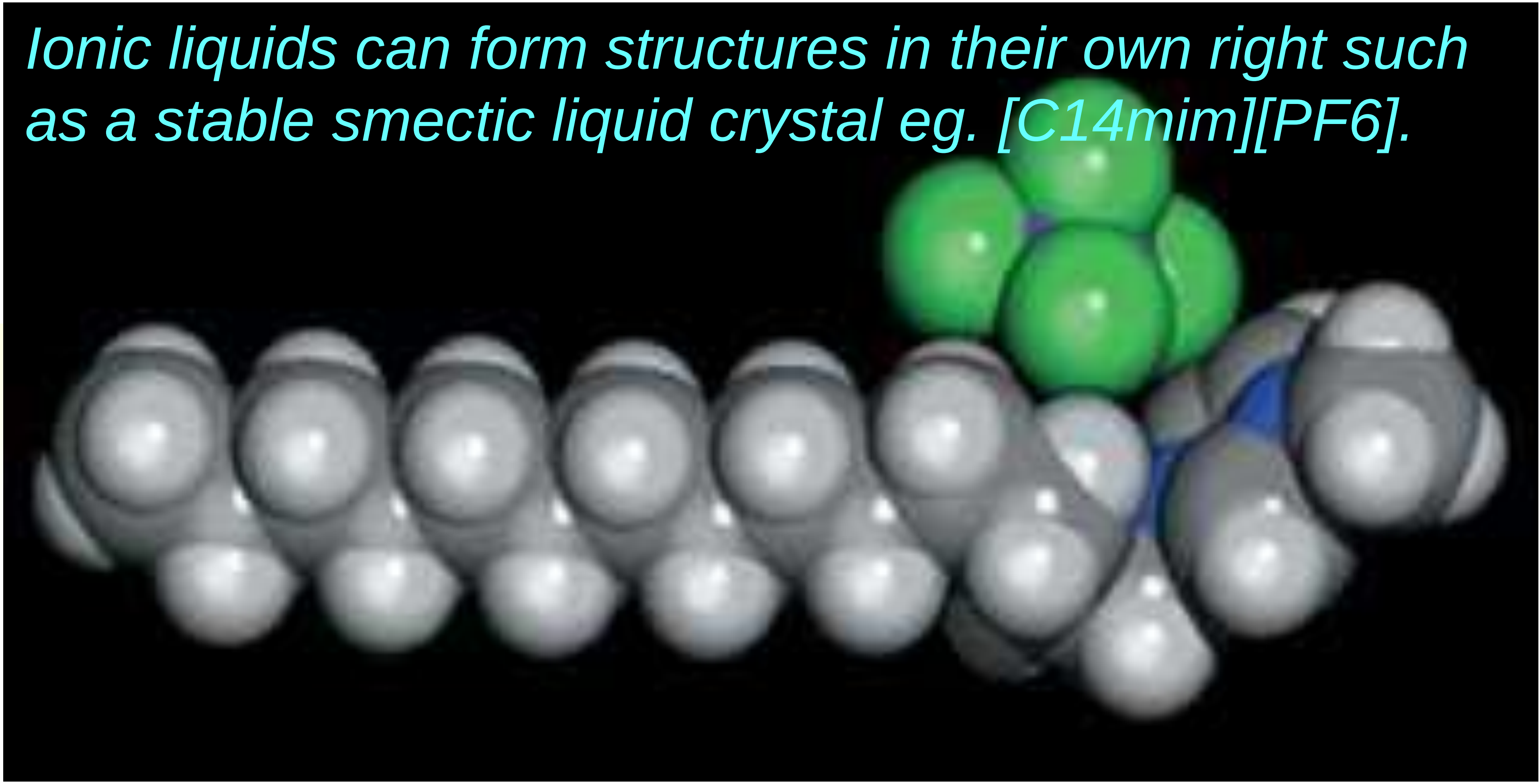
- The Solvents which can eliminate or decrease the mentioned problems are generally known as Green Solvents.

Few of the green solvents are:

- ✓ Solventless.
- ✓ Super Critical $CO_2$ Solvent
- ✓ Water
- ✓ Ionic Liquids

# IONIC LIQUIDS

- Tunability – by varying the cation/anion ratio, type and alkyl chain length properties such as acidity/basicity, melting temperature and viscosity can be varied to meet particular demands.
- Many ionic liquids are stable at temperatures over 300 °C, providing the opportunity to carry out high-temperature reactions at low pressure.
- Ionic liquids that are not miscible with organic solvents or water may be used to aid product separation or used in liquid–liquid extraction processes.
- For a given cation the density and viscosity of an ionic liquid are dependent on the anion; in general density increases in the order $BF_4^- < PF_6^- < (CF_3SO_2)_2N$ and viscosity increases in the order $(CF_3SO_2)_2N < BF_4^- < PF_6^- < NO_3^-$.




***Ionic liquids made of dialkylimidazolium cations and appropriate anions are useful alternative media of special properties to be employed.***

# Strategies of solvent replacement

- Avoid or minimise solvents in beginning of reaction.
- Use less toxic solvents
- Use renewable solvents (not derived from petrochemicals)
- Avoid VOC's – solvents with low vapour pressure / high boiling points may be preferable as long as this does not lead to other complications.

# Various Green Solvents.

- Solventless
- Water
- Carbon dioxide
- Ionic liquids

***All have advantages and disadvantages which need to be considered when assessing suitability for replacement***

# Solventless Chemistry

## Advantage

- No harmful waste liquid.
- Economic reaction.
- Save time.

## Disadvantage

- Not many reactions amenable to solventless approach, particularly on large scale
- Exothermic reactions can be dangerous on large scale. Solvents are better heat sinks.
- Efficient mixing can be a problem, particularly when have solid reagents or products
- Solvents still often required for extraction, separation and purification of products

# VOC Alternatives

Most solvents used today are volatile organic compounds (VOCs). VOCs readily escape to the atmosphere when used causing a substantial fraction of all air pollution. Eliminating VOCs is environmentally desirable but requires that practical and economical VOC solvent alternatives be developed.

Supercritical water and supercritical carbon dioxide ($CO_2$) continue to provide successful green approaches for replacing VOCs in chemical processes such as decaffeinating coffee, dry cleaning and demanding chemical reactions.

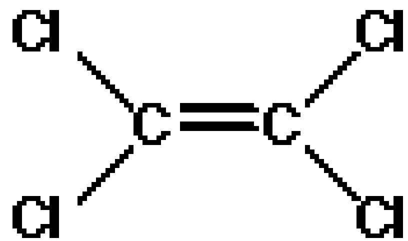
R. Rogers and others have developed a new class of solvents called room-temperature ionic liquids (RTILs). Many RTILs are based on chloroaluminate anions or alkyl imidoazolium cations. Most RTILs exhibit a low melting point, a high boiling point, and a high viscosity.

As solvents, RTILs have extremely low vapor pressures, an important green feature for replacing VOCs and decreasing atmospheric pollution. Many of the chemical properties of ionic liquids such as tunable polarity, good dissolving power for organic molecule, and easy drying are identical to those of VOCs. The major hurdles for commercialization of RTILs are cost limited toxicological data.

A technique that uses soap and water to degrease silicon wafer, thereby avoiding the use of chlorinatedfluorocarbons(CFCs or freons)during semiconductor manufacturing. Another CFC-free wafer-cleaning technology has been developed by J.DeSimone that uses surfactant and supercritical $CO_2$ as the solvent.

# GREEN CHEMISTRY

- Dry Cleaning




  - Initially gasoline and kerosene were used
  - Chlorinated solvents are now used, such as perc

  - Supercritical/liquid carbon dioxide ($CO_2$); *infusing green chemistry into general chemistry*

# Carbon Dioxide

Advantage

- Natural, cheap, plentiful
- Available in >99.9% pure form.
- By-product of brewing, ammonia synthesis, combustion
- Already being adopted in a variety of commercial processes
- Non-toxic and properties well understood.
- Easily removed and recycled and can be disposed of with no net increase in global $CO_2$. Simple product isolation by evaporation, to 100% dryness.
- No solvent effluent
- Potential for product processing (extraction, particle formation, chromatography etc.)

# Other advantages of $scCO_2$

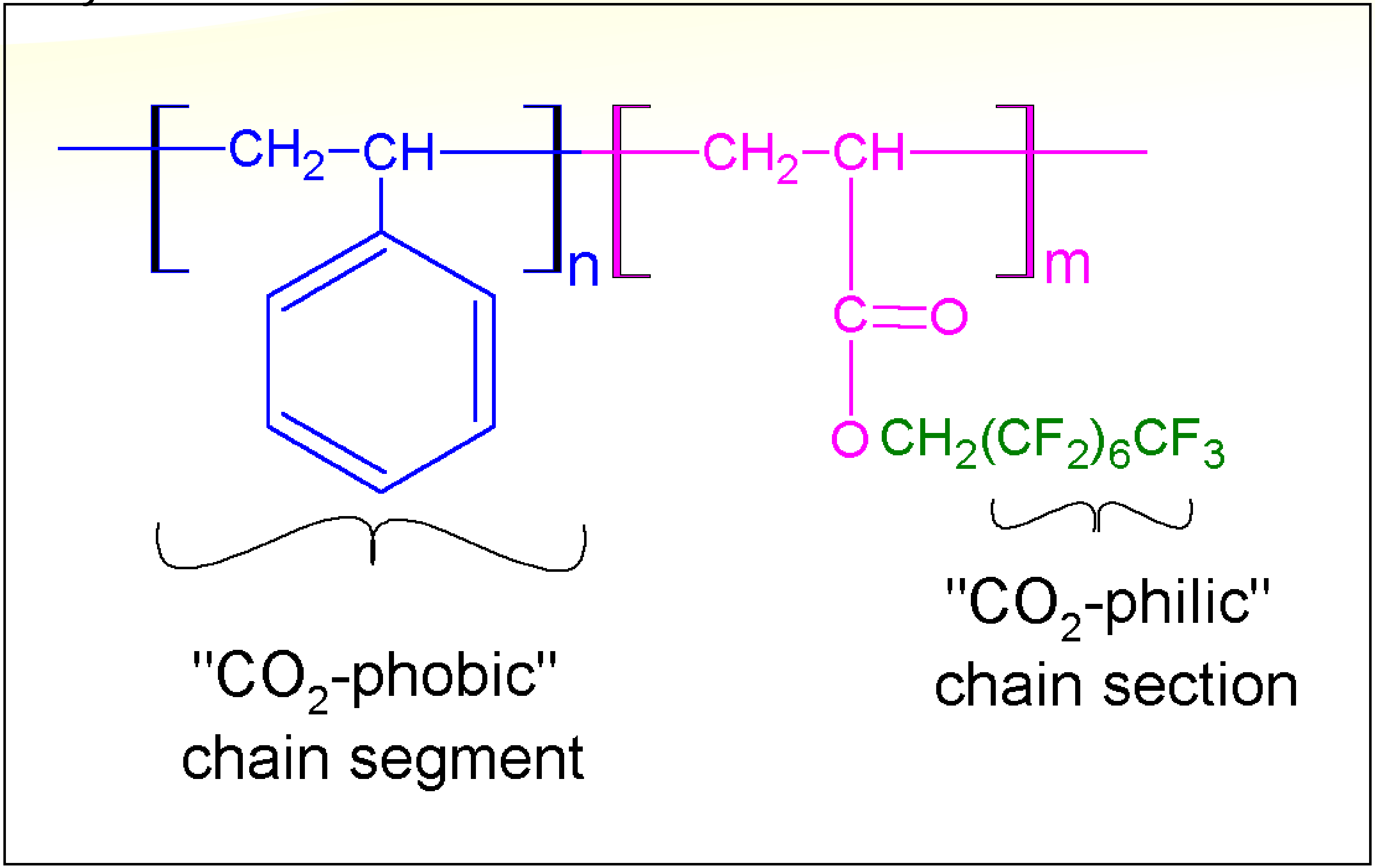
- **High compressibility**
  - Large change in solvent properties for relatively small change in pressure – infinite range of solvent properties available
  - Ability to tune solvent to favour a particular reaction pathway simply by optimising temperature or pressure
- Small amounts of **cosolvents can further modify solvent properties**
- **High diffusion rates** offer potential for increased reaction rates.
- Potential for homogeneous catalytic processes.
  - High solubility of light gases, some catalysts and substrates; bring all together in single homogeneous phase
- Inert to oxidation; resistant to reduction
  - Excellent medium for oxidation and reduction reactions.

## Liquid Carbon Dioxide as a solvent

It may seem strange at first to think of CO2 as a solvent. You are probably familiar with .CO2 as either a gas in the air we exhale, or as a solid called dry ice.

Carbondioxide freezes at-78.4°C. If dry ice is touched it freezes skin rapidly, destroying the skin tissue. Because the resulting damage looks like a burn, some people have the misconception that dry ice will ‘burn’ you.

Joseph of the University of North Carolina surfactant polymers to have a "CO2-philic" end, which is attracted to liquid CO2, and a ‘CO2-phobic' end, which is not attracted to CO2 but to fats. greases and oils.
Allow CO2 to replace PERC as a dry cleaning solvent, in green chemistry.



Hangers®
CLEANERS

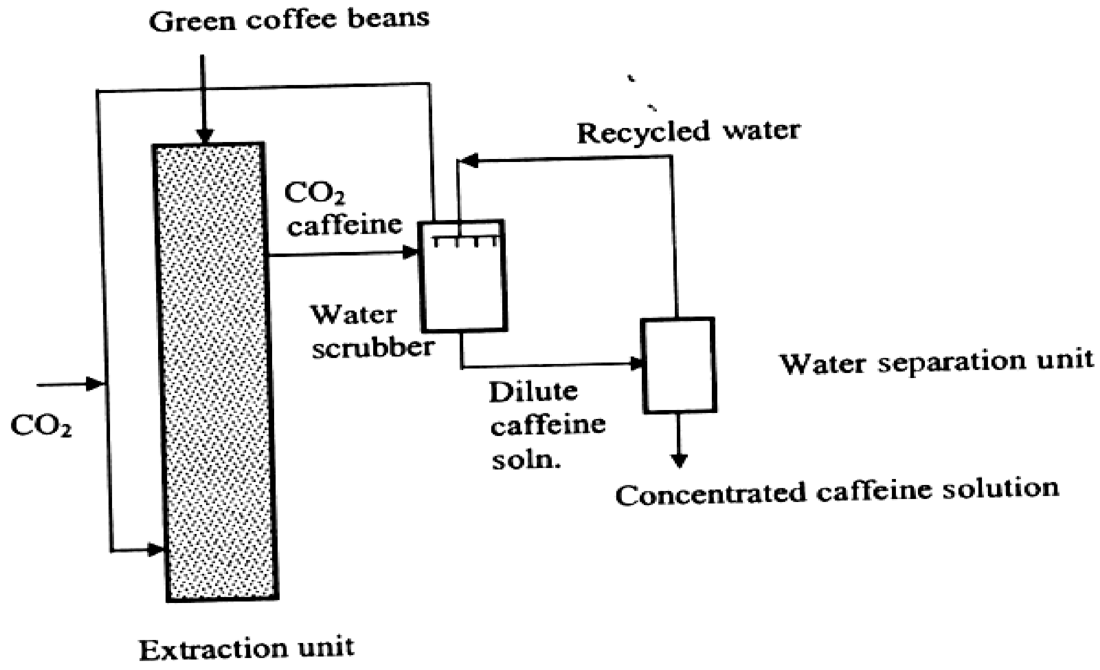

- http://www.hangersdrycleaners.com/

# Environmental/Economic Advantages of Liquid $CO_2$

- Using $CO_2$ eliminates hazardous waste generation of Perchloroethylene (PERC).
- $CO_2$ does not pose the environmental and human health risks associated with PERC (used by 34,000 dry cleaners in US).
- Using the Hangers $CO_2$ process lowers energy consumption.
- Using $CO_2$ reduces environmental regulatory burdens for Hangers operators.
- Uses waste $CO_2$ from other processes.

# Decaffeination of Coffee

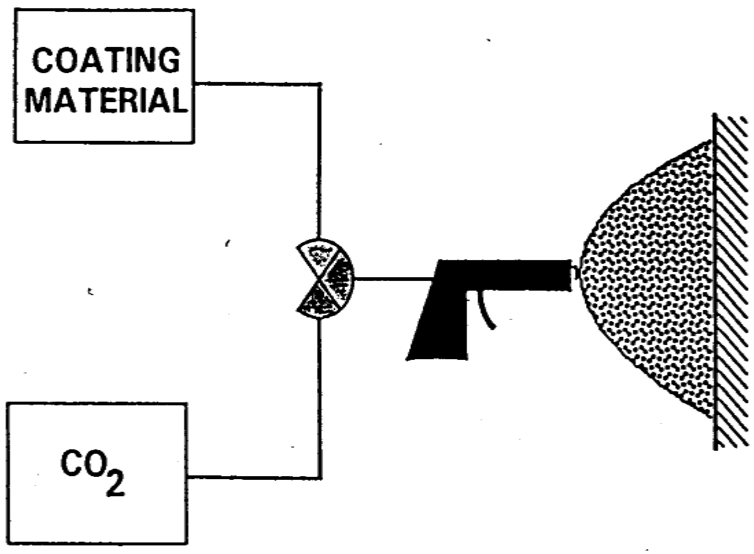
One of the most widely established processes using scCO2 is the decaffeination of coffee. In the 1980s the preferred extraction solvent was dichloromethane. Adverse health effects of chlorinated materials were realized. Hence the current processes offer health, environment and economic advantages. Reverse osmosis or membrane technology to concentrate the aqueous solution. Whilst scCO2- selectively extracts caffeine from green coffee beans it co-extracts many of the aroma oils produced on roasting if carried out after the roasting process.



# A New Process Using Supercritical Carbondioxide to Replace Traditional Paint Solvents

A new process for spraying paints and other coatings has been developed which reduces atmospheric emissions of environmentally harmful volatile organic compounds (VOCs). The liquid solvents of conventional coatings have been replaced by supercritical Carbondioxide. The carbon dioxide not only reduces viscosity, but provides additional benefits. The resulting coatings have uniform thickness and excellent coalescence

Volatile organic compounds (VOCs) are a class of air pollutants. Every year, American industries spray 1.5 billion liters of coatings and paints, which release an average of 550 grams of VOC solvents for each liter sprayed. As many VOC solvents are hazardous a



# Advantages and Disadvantages of using scCO2 as a solvent

**Advantages**: -

Non-toxic

Easily removed

Potentially recyclable

Non-inflammable

**Disadvantages: -**

Relatively high pressure equipment

Equipment can be capital intensive

# Desirable Properties

- Negligible vapour pressure
- Non-volatile
- Non-flammable
- High thermal, chemical and electrochemical stability
- Liquid over a wide temperature range
- Dissolution of many organic and inorganic compounds
- Variable miscibility with water and organic solvents


Some Organic reactions studied in ionic liquids
Nucleophilic substitution
Heck reaction
Ene reaction
Electrophilic substitution
Hydroformulation
Friedel-Craft
Hydrogenation
Cracking and isomerization
Epoxidation
Electrophilic nitration
Diels Alder
Electrophilic halogenation
Oxidation reactions
Electrocyclic reactions
Reduction reactions
Nucleophilic addition
ondensation
Mannich reaction
Hetero Diels Alder

# Ultrasound Assisted Green Synthesis

**Introduction :-**

The word ‘ultrasound’ has become common knowledge due to the widespread use of ultrasound scanning equipments in medical applications. Ultrasound refers to sound waves having frequencies higher than those to which the human ear can respond (μ, > 16 KHz) (Hz = Hertz = cycles per second). High frequency ultrasound waves are used in medical equipments. The ultrasound frequencies of interest for chemical reactions (about 20-100 KHz) are much lower than those used for medical applications, but the power used is higher

The ultrasound is generated with the help of an instrument having an ultrasonic transducer, a device by which electrical or mechanical energy can be converted into sound energy. The most commonly used are the electromechanical transducer which converts energy into sound - they are mostly made of quartz and are commonly based on the piezoelectric effect.

The term ‘sonochemistry’ is used to describe the effect of ultrasound waves on chemical reactivity. A number of reviews on the chemical applications of ultrasound have been published.

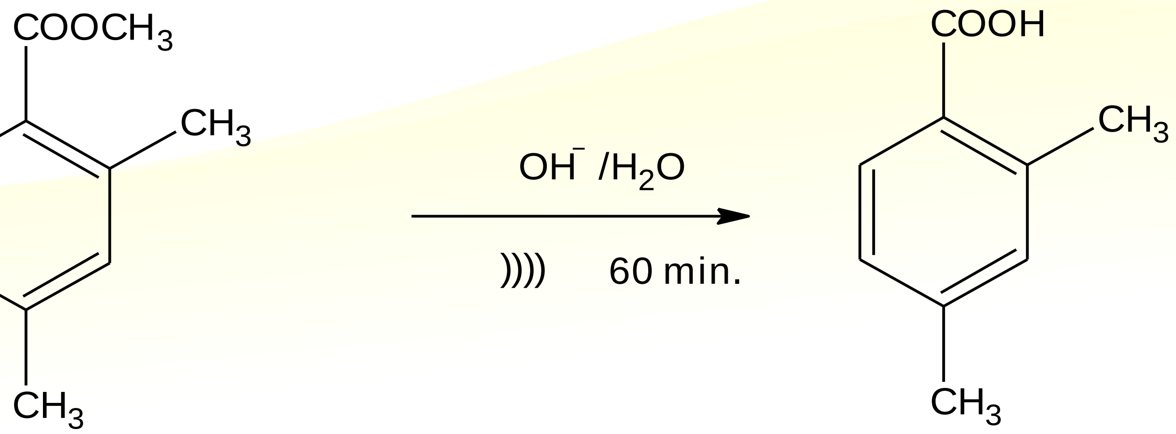
# Applications of Ultrasound

Following are some of the important applications of ultrasound in chemical synthesis. Most of the reactions/synthesis reported are carried out at room temperature unless otherwise specified. The symbol )))) is used for reactions carried out on exposure to ultrasound.

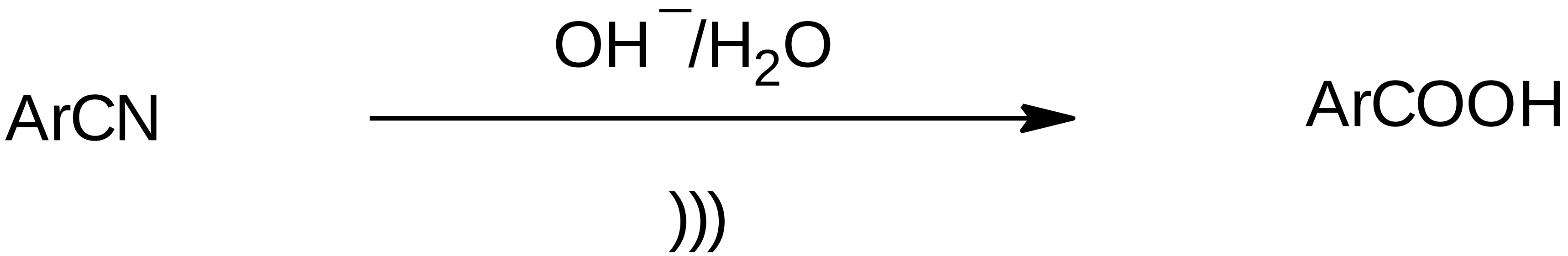
## Esterification: -

$$RCOOH + R'OH \xrightarrow[))))]{H_2SO_4,\ R.T.} RCOOR'$$

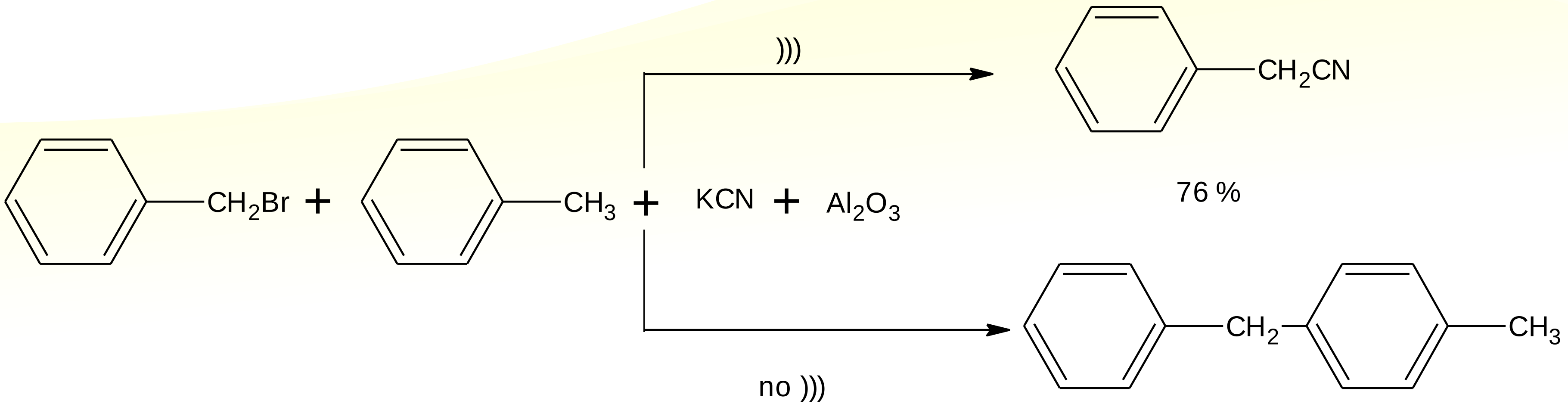
# Saponification:



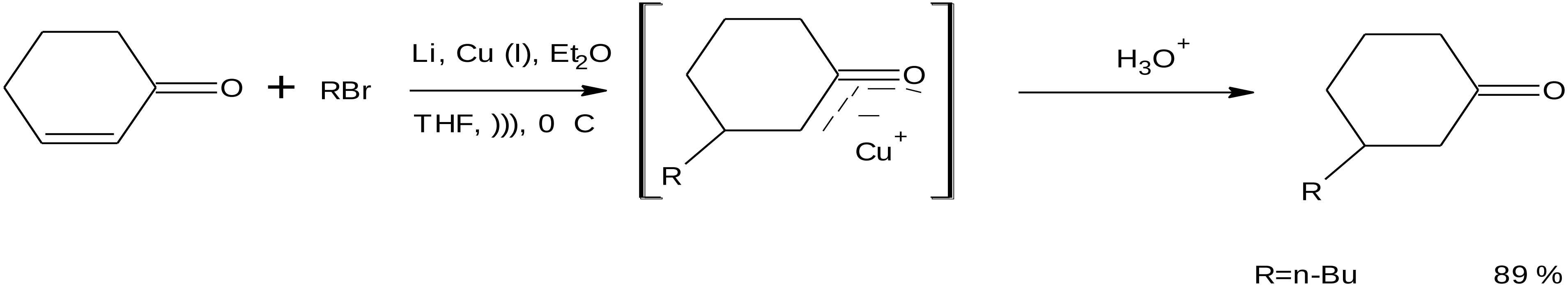

# Hydrolysis:



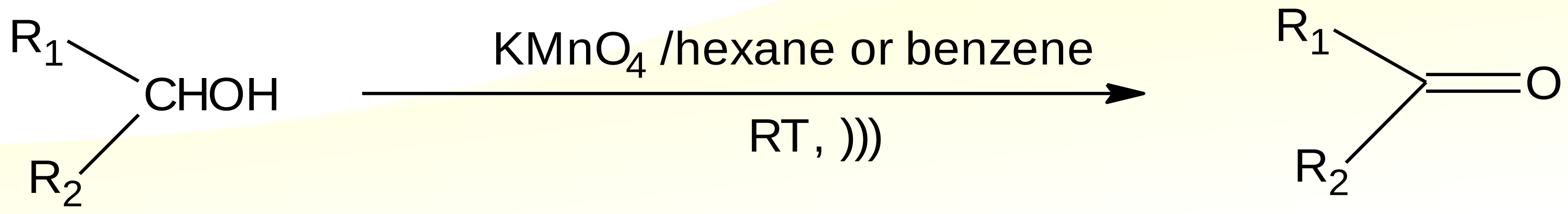
# Substitution Reactions: -



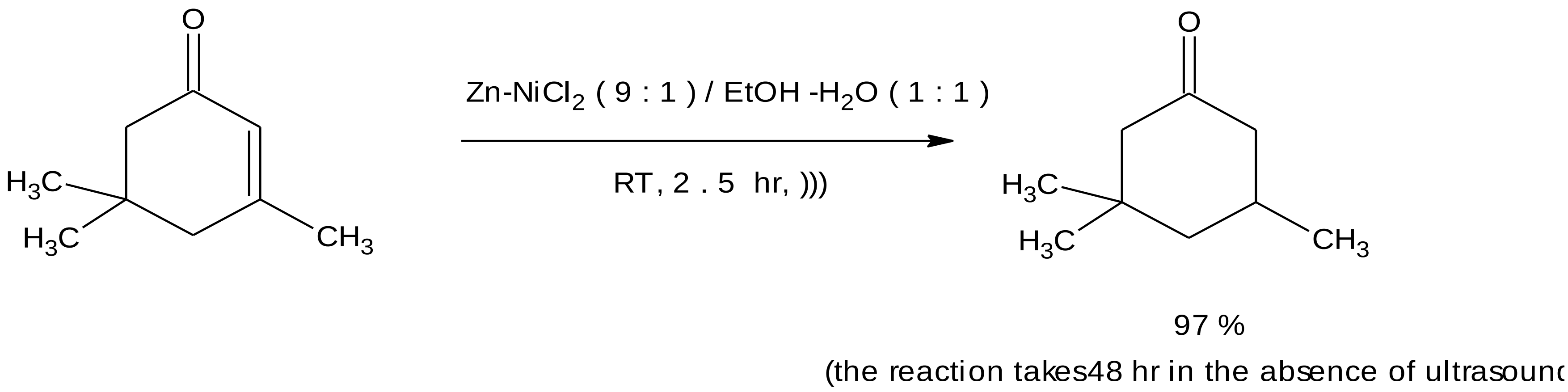

# Addition Reactions: -



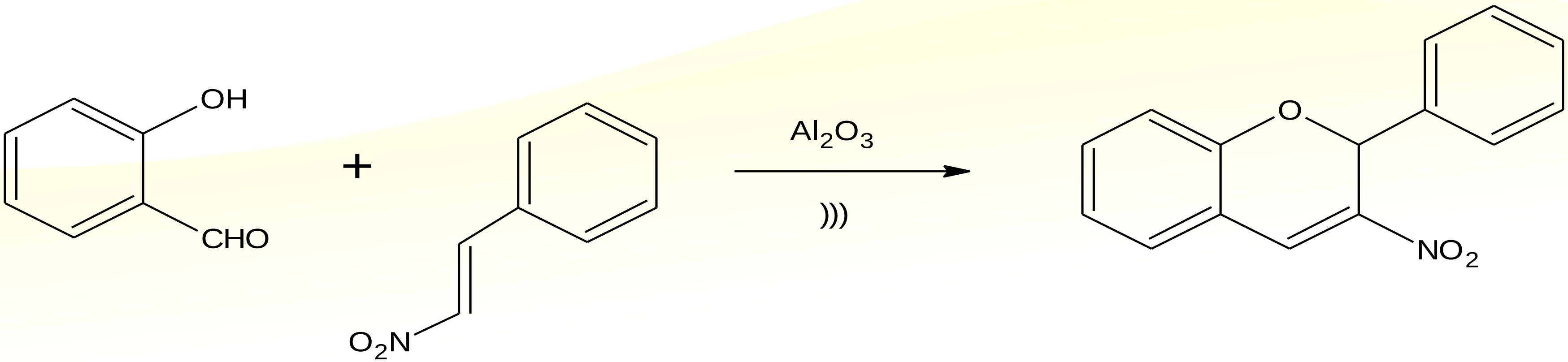
# Oxidation:




# Reduction:



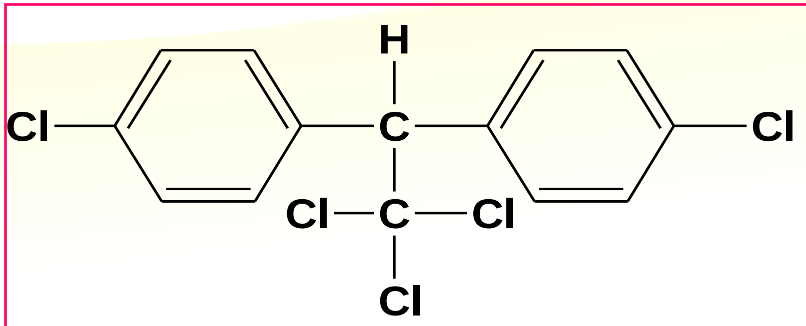
# Synthesis of Chromenes:




# Conclusion:

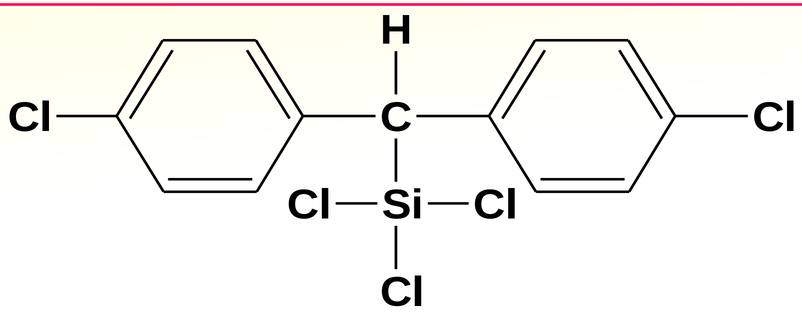
Ultrasound assisted organic synthesis gives excellent yields compared to other reactions. It can dramatically affect the rates of chemical reactions and is helpful for a large number of organic transformations. In fact, a combination of sonication with other techniques, e.g., phase transfer techniques, reactions in aqueous media etc. give best results. Sonication has also been shown to stimulated microbiological reactions.

# Eco-friendly Insecticide:




**DDT**

**Dichloro-diphenyl-trichloroethane**



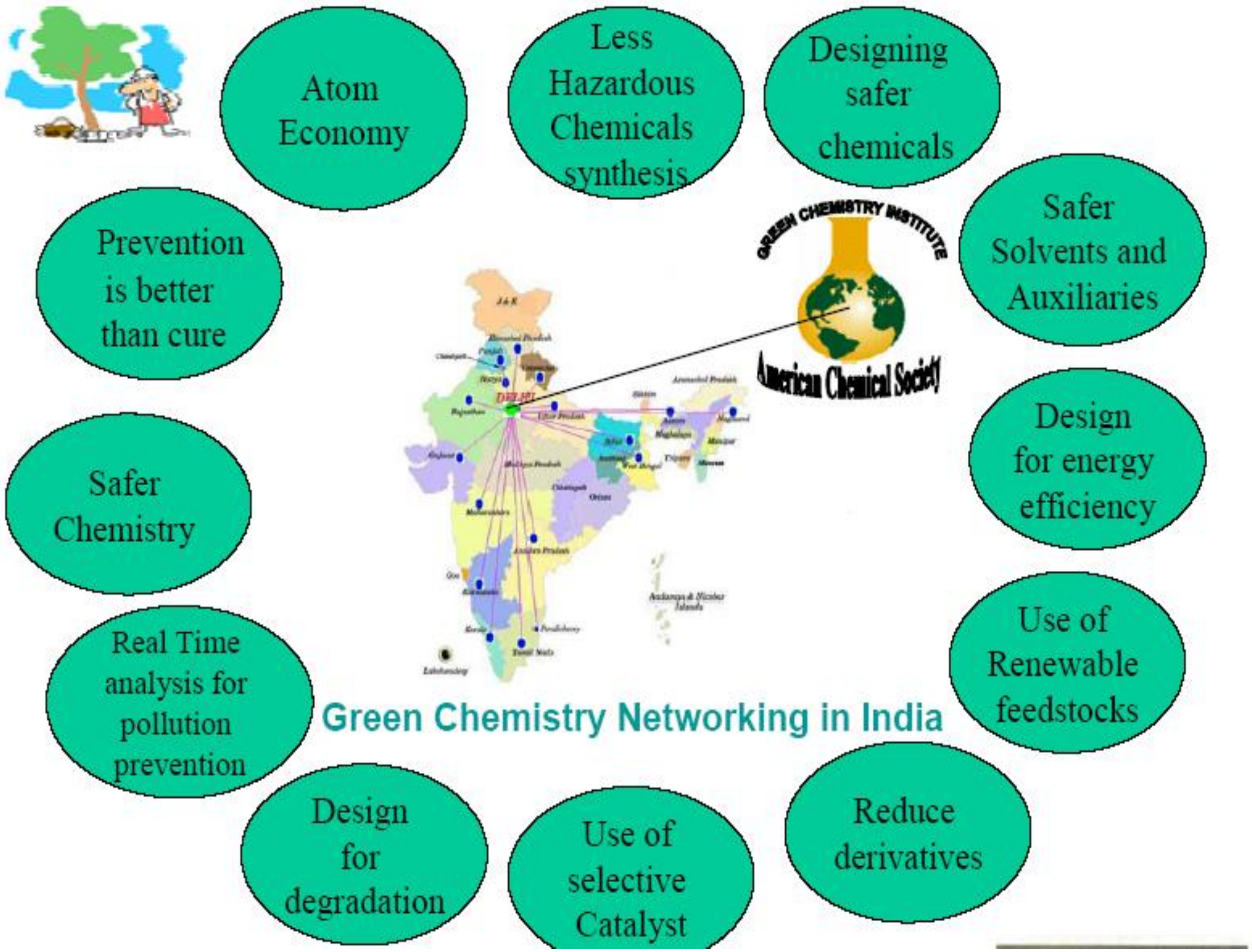

**Dichloro-diphenyl-trichlorosilicon ethane**

It is prevent growth of plants insects.

It is harmful and mutagenic for cell growth of human being and animals

It is prevent growth of plants insects.
It is not harmful and not mutagenic for cell growth

# Green Chemistry Network in India



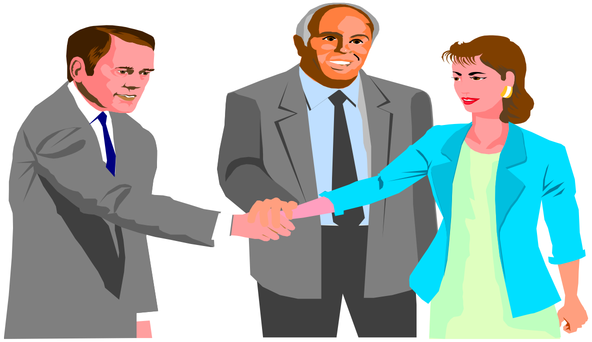
**The Day is not far off!!**
**Act Now to prevent it**

# மிக்க நன்றி !!
# அ. மனோகரன்

**SIN Q**

**---------- = TAN Q**

**COS Q**



**A. MANOHARAN**

**e- mail** mano_cpcb@yahoo.co.in

**C U AGAIN**

**BYE BYE**


THANK
YOU
© Rolf Hicker

# Why “End of the Pipe Treatment?”

## Impact: huge threat to water bodies & human health

- Quantity – 25 to 100 bn kgs per annum only from Pharma
- Outcome – converting one kind of effluent in to other
- Toxicity – not fully known (Ecotoxicity data available for less than 1% of human pharmaceuticals
(Ref: Journal “Regulatory Toxicology & Pharmacology, April’ 2004)”
- Degradation – very slow, impact unknown after degradation

## Examples:

- Feb 2009, Pharma Zone in Central India – River water sample analyzed by a Professor from Sweden. This supposedly treated water was a soup of 21 different APIs.
    - 2007, River in China – effluent from a contraceptive manufacturing plant contained 10 times of Oestrogen required to collapse fish population.