Hello everyone, myself Nutan Patil
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this module is for semester five third
year BSc chemistry students, course code
is CHD 102, course title is green methods
and safety aspects in chemistry.
title of the unit is real world cases in
green chemistry and module name is
surfactants for carbon dioxide for precision cleaning and dry
cleaning of garments.
So, after this session
you will learn about the hazardous
volatile organic solvent used for
precision cleaning and dry cleaning of
garments,
replacement of smoke producing and ozone
depleting solvents with carbon dioxide.
surfactant used for carbon dioxide which
is used in precision cleaning and dry
cleaning of garments.
after this session students will be able
to describe this real-world case.
students will also understand the
importance of carbon dioxide as a
substitute for volatile organic solvents
in precision cleaning and dry cleaning
of garments in industries. They will also
learn the role of surfactant in liquid
or supercritical carbon dioxide.
since this is a real-world case first
we'll see the problem and what is the
solution for this problem.
Use of volatile organic compounds,
halogenated organic compounds such as
CFCS, HCFCS and perchloroethylene is used
in precision cleaning or dry cleaning
industries.
so this volatile organic compounds are
responsible to cause air pollution. as
they constitute the ingredient of the
photochemical smog ,. CFCS, HCFCS are ozone
depleting substances and many organic
compounds such as perchloroethylene  are groundwater
contaminants and potential carcinogens.
so what is the  solution for this problem?
professor Joseph m DeSimone from
university of north Carolina and north
Carolina state university and also
founder of missiles technology, he has
designed the surfactant and has made the
use of supercritical and liquid $CO_2$ as a
industrial solvent.
so while using this surfactant
solubility of various material can be
increased in carbon dioxide and
replacement of the current industrial
solvent with this carbon dioxide has led
to reduce environmental risk.
now we will see the hazards of
industrial solvents .we know that

volatile organic solvents which are used as xylene, toluene, benzene, ethylene they are used as a cleaning fluid because they dissolve oils ,waxes and greases. they readily evaporate from the items they are being used to clean so there is no need to heat the delicate items. As per the reports ,in USA and Canada, about 26 million tons of volatile organic compounds rare released into the atmosphere per year and about one-fourth of these emissions are from industrial processes.

when these volatile organic compounds mix with sunlight and nitrogen oxide ,they gets converted to ground level ozone, nitric acid and partially oxidized organic compounds. so this product mixture is called as photochemical smog.

Exposure to this smoke aggravates asthma, induce other respiratory elements and also it leads to cancer.

smog increases the level of tropospheric ozone which may damage the crops, harden rubber and discolor the fabric.so i have given the below reaction.

now use of CFCS and HCFS are also responsible for this environmental problem. so we'll see how it is responsible.

cfcs are photochemically decomposed by this uv rays to give chlorine radicals which acts as a catalyst to destroy the ozone layer.

so further resulting the chlorine monoxide radical reacts with an oxygen atom to form oxygen molecule and it regenerates the chlorine radical. so these steps are repeated due to which there is a significant loss of this ozone layer.

now all these steps i have given here. step one, two and three which indicates that how there is a loss of ozone layer. depletion of ozone is responsible for the uv-b rays to reach earth's surface and prolonged exposure to this uv-b rays causes skin cancer and cataracts among humans

so why not to go for this carbon dioxide as a alternative solvent to this volatile organic compound or halogenated organic compounds

now we'll see carbon dioxide as an alternative solvent.

carbon dioxide is non-flammable, non-toxic and chemically unreactive it does not contribute to the formation of photochemical smog nor it depletes the stratospheric ozone.

it is easily available as a byproduct

from the production of ammonia and also
from natural gas wells. it can be easily
evaporated and can be recovered purified
and reused.
so very less amount of energy is needed
here.
the use of carbon dioxide as a solvent
it requires the gaseous carbon dioxide
to be converted into liquid or
supercritical state.
if the substance is placed at a
temperature above its critical
temperature and critical pressure
a supercritical fluid is formed.
now we'll see the solubility of
substances in carbon dioxide as we know
carbon dioxide is a non-polar molecule
so it will dissolve non-polar molecule
in it but carbon dioxide when it is in
liquid and supercritical state will not
dissolve larger molecules such as all
waxes, grease
polymer polar material
due to which we have to use surfactant.
so we can increase the solubility of
this substances in liquid as well as
supercritical carbon dioxide.
now what is a surfactant?
a surfactant has a one end similar to the polarity of
the particle to be emulsified and the
other end similar to the polarity of the
solvent. so, in water surfactant molecules
tend to cluster into a spherical
geometry wherein the non-polar ends lie
on the inside of the sphere while the
polar ends on the outside. so, these
clusters are called as missiles so the
figure a show the micelle structure of
surfactant. so, we can take example here
as soaps and detergents in water..they are
used to cleanse the grease and oil.
now surfactant for liquid or super critical
carbon dioxide it must have both carbon
dioxide phillic  as well as carbon
dioxide phobic functionality. so
professor Desimone discovered fluoro
polymer which is soluble in carbon
dioxide due to the weak Vander Waals
forces exist between carbon dioxide and
same forces exist between the fluoro
carbon tail so. i have given here the
structure which is carbon dioxide philic
fluorocarbon in figure b
now the block
copolymer is synthesized
by professor Desimone has a polystyrene
block that are
insoluble in carbon dioxide and poly 1,1
 dihydroperfluorooctyll
acrylate graft segment that is soluble
in carbon dioxide .it is shown on the
next slide.

when this polymer or the copolymer is placed in a medium of liquid or supercritical carbon dioxide it will arrange itself in a micelle structure.
so here carbon dioxide soluble segment surrounds the carbon dioxide insoluble segment.
so depending upon the type of material to be dissolved carbon dioxide phobic segment can be made lipophilic or it can be made hydrophilic.
so here use of surfactant increases the solubility of waxes, grease, oil and carbon dioxide. Here carbon dioxide insoluble material it gets trapped in the micelle structure and it is carried away in the liquid carbon dioxide or supercritical carbon dioxide solvent.
This technology has potential to replace the smoke producing and ozone depleting industrial solvents.
now this is the structure of carbon dioxide surfactant where in the $CO_2$ phobic segment is there that is polystyrene block here or $CO_2$ philic segment is that the fluorocarbon in the figure d micelle structure for a carbon dioxide surfactant .so here carbon dioxide solvent
then next carbon dioxide phobic chain segment there it is depicted in black color.
$CO_2$ phillic chain segment inside is depicted or shown as a red or green color. .you all can just compare with the structure given here in the figure c.
now current use of carbon dioxide surfactant and how the green chemistry comes into action we have to see.
missile technologies a company founded by Joseph Desimone, Timothy Romack and James McClain has made the commercial use of this carbon dioxide surfactant technology so they have developed dry cleaning machines as well as metal cleaning system.
that utilizes carbon dioxide and or surfactant
so due to which there is elimination of PERC okay it is used in dry cleaning of garments and other halogenated solvents in industry.
Due to this discovery
design and application of surfactant for carbon dioxide they won a prestigious presidential green chemistry award in 1997.
these are my references.
thank you