

Extra data

Research

Industry

Networking

Education



Purpose of this slide deck

- Equip you with extra knowledge for those students who want to know more
- Increase understanding of aspects of Green Chemistry
- Point towards further reading
- Contacts
 - Chemistry rob.mcelroy@york.ac.uk
 - Comic J.A.Lawrence@tees.ac.uk

Research

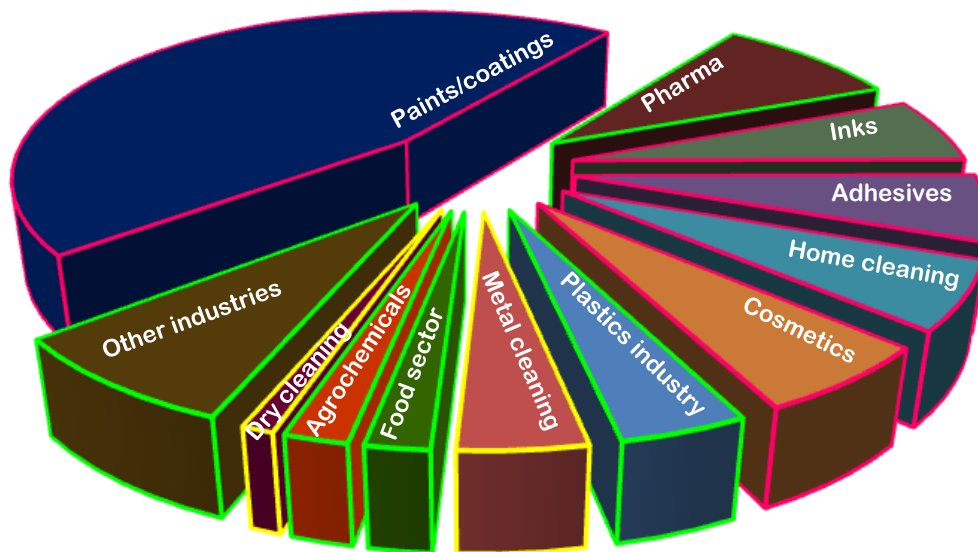
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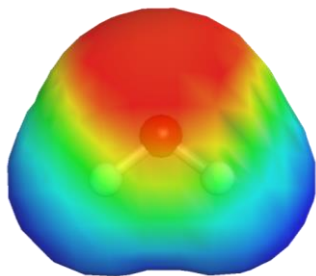
Education



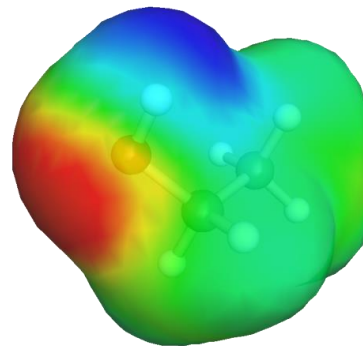
Non water solvent market 20 million tones year⁻¹



Electron map of solvents



Water

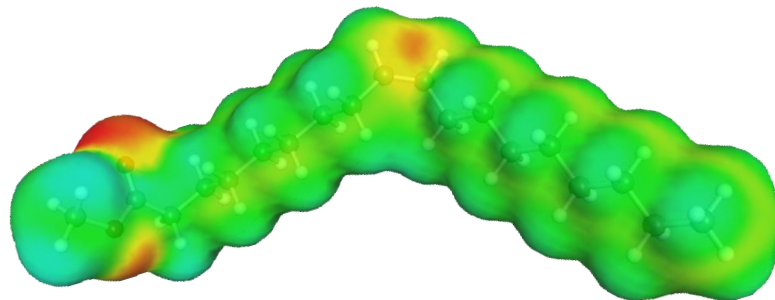


Ethanol

- What we call “protic” solvents because there is a strong dipole - red is electronegative, blue is electropositive.
- A blue hydrogen (a proton) is very electronegative and as such, reactive.



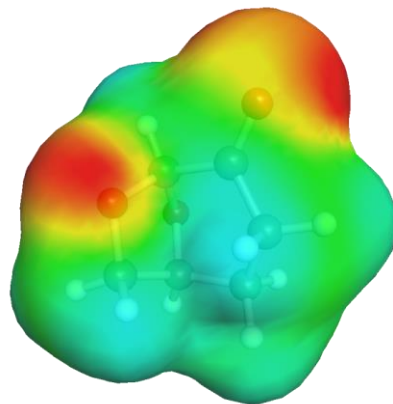
Greasy solvent (hydrocarbon)



- This is methyl oleate (methyl ester of an 18:1 fatty acid), more commonly known as biodiesel (it's the most common component).
- It has some electronegativity round the ester (red) and some at the double bond, but is mainly non polar (green).
- Green wants to be with green and blue red want to be with red blue, that's why water and oil don't mix.



Polar aprotic



- This is Cyrene™ which is polar, it has a dipole (partial positive and negative charges), but it doesn't have a blue (reactive) proton.
- Cyrene is important because most polar aprotics are under regulation (very much controlled by REACH) because they are dangerous to pregnant people and animals.
- Cyrene is one of a small number of safer polar aprotics.

Why do we need polar aprotics

- They are used to make active pharmaceuticals (drugs/medicines)
- We need them to make lithium ion batteries e.g. in your phones
- We need them to make graphene (lots of uses)
- We need them to make special plastics
- They are used in lots of exciting discoveries e.g. printable electronics

Research

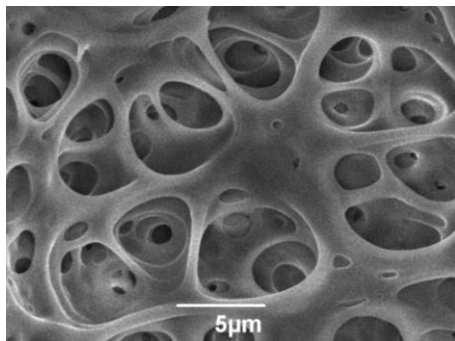
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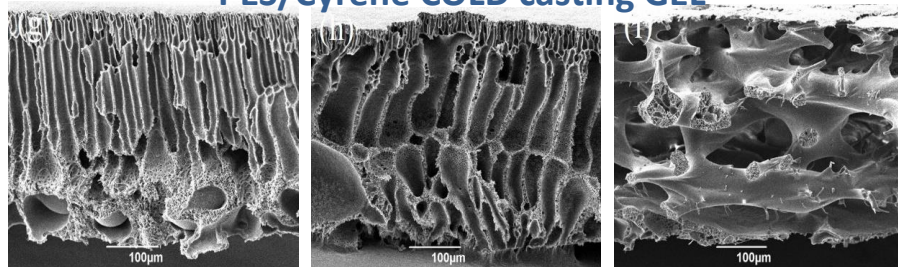
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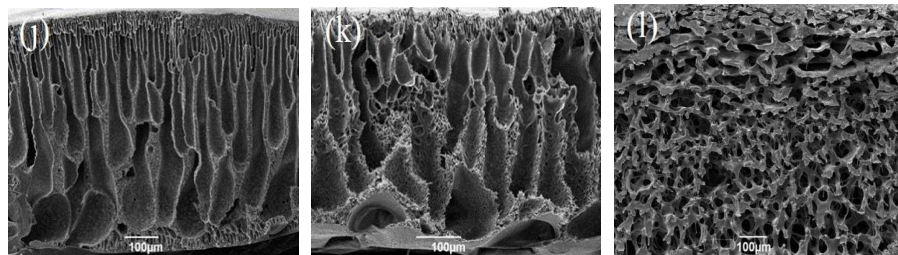
Cyrene -based membrane



PES/Cyrene COLD casting GEL



PES/Cyrene HOT casting GEL

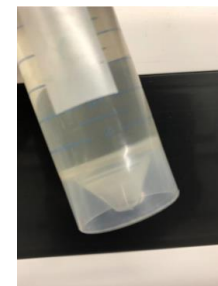
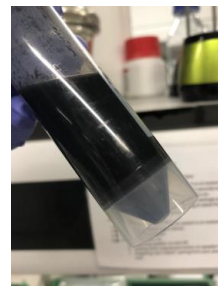
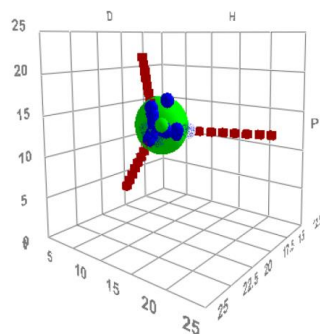


These are materials made from a very tough plastic where you can make different size pores to filter different size stuff.
e.g. g, j ultrafiltration (bacteria)
i, l microfiltration

Battery Recycling

Working solvent model

$\delta D - 18.2$
 $\delta P - 13.2$
 $\delta H - 8.8$
Radius 3.8



Black mass and PVDF recovery in green solvents

Cathode production in green solvents



This work showed selection of green solvents to recycle the electrodes from old Lithium Ion batteries and also allows for fabrication of new batteries.

Lignocellulosic feedstock

- The most abundant bioderived feedstock on the planet is lignocellulosic biomass, with an annual production in excess of 185.1 billion tonnes.
- Encompasses all plant material from woodland, to agricultural residues to grasses and garden waste.
- The exact composition of lignocellulosic material varies from species to species, although in all cases the most common constituent is cellulose.
 - Cellulose is a polymer consisting mainly of 1–4 linked C6 glucopyranose units.
- Hemicellulose, a mix of C6 and C5 cyclic sugars, coats the cellulose.
 - the exact nature of hemicellulose varies, in softwood its mainly d-mannose and d-glucose, in hardwood its xylose alongside α -arabinofuranose and α -glucuronic acid.
- The third major constituent is lignin, usually forming within the biomass once growth is complete.
 - This is the stuff that makes e.g. old basil woody and hard to eat.
 - Lignin gives structural reinforcement and making the plant less susceptible to environmental stresses.

Research

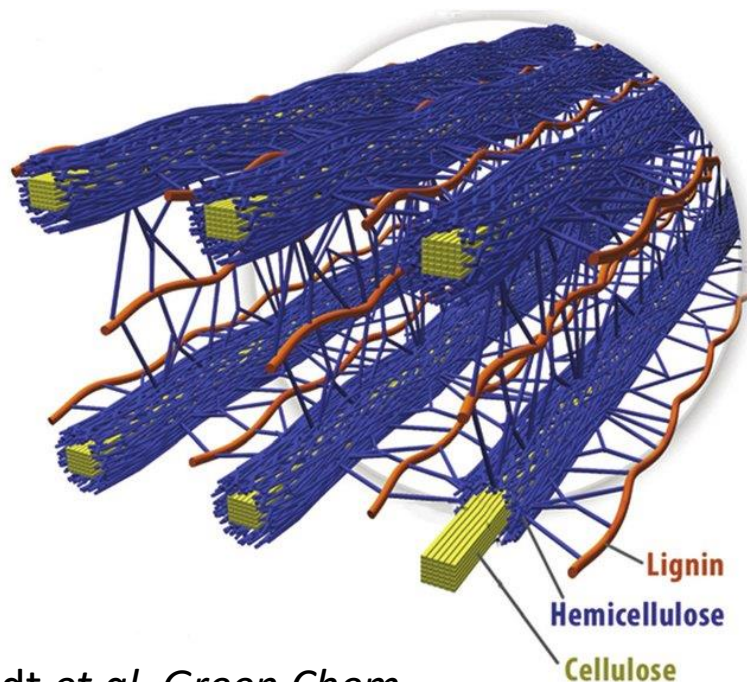
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Structure of lignocellulose



Taken from Brandt *et al*, *Green Chem.*,
2013,15, 550-583

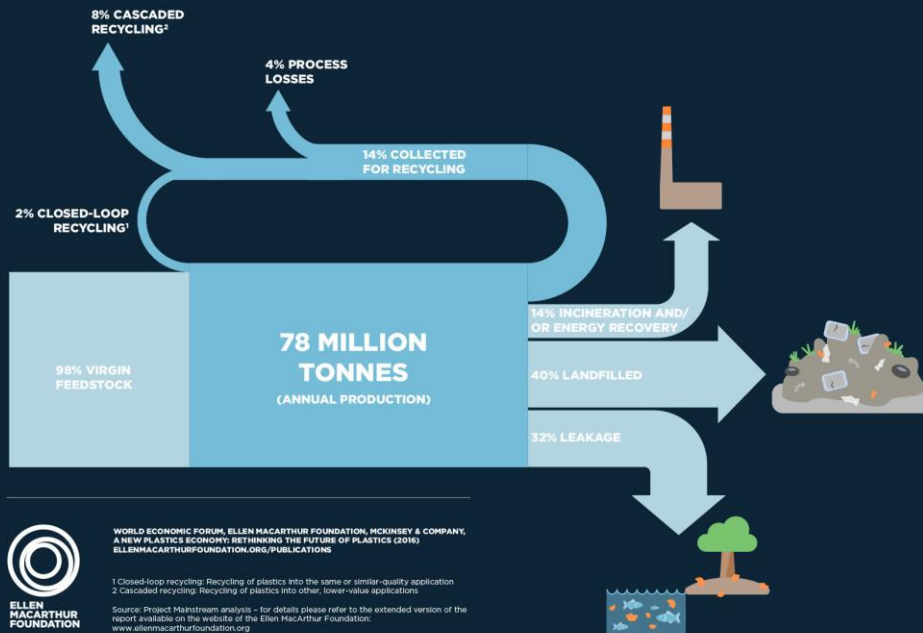
Circular economy



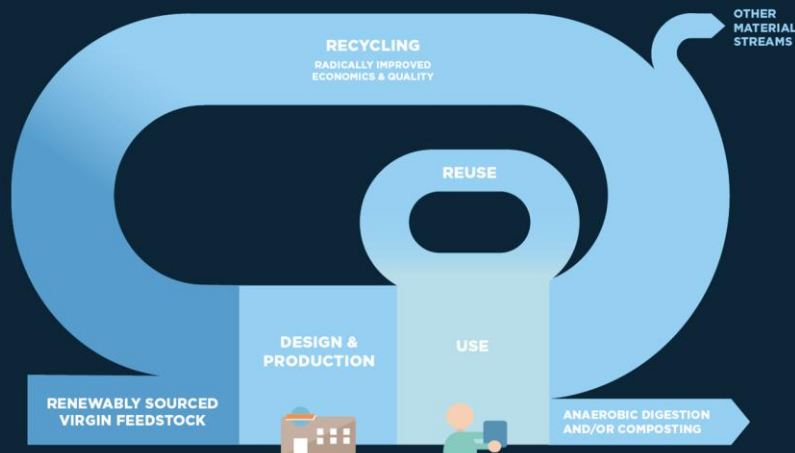
- Circular economy - a closed loop, at the end of life, things can be made back into new things
- Linear economy - take, make, use, lose
- Lots of info out there
 - Best place to find more (like image) is <https://ellenmacarthurfoundation.org>

Example – plastics linear

TODAY, PLASTIC PACKAGING MATERIAL FLOWS ARE LARGELY LINEAR



A CIRCULAR ECONOMY FOR PLASTIC



WORLD ECONOMIC FORUM, ELLEN MACARTHUR FOUNDATION, MCKINSEY & COMPANY,
A NEW PLASTICS ECONOMY: RETHINKING THE FUTURE OF PLASTICS (2016)
ELLENMACARTHURFOUNDATION.ORG/PUBLICATIONS



Pyrolysis

- heating something up, but not in air, so that it chemically changes but doesn't burn
- Used in industry a lot
 - Called cracking when breaking down petrochemicals to smaller compounds
 - Is being used to chemically recycle plastics
 - Starting to see more factories making fuels and chemicals from biomass

Research

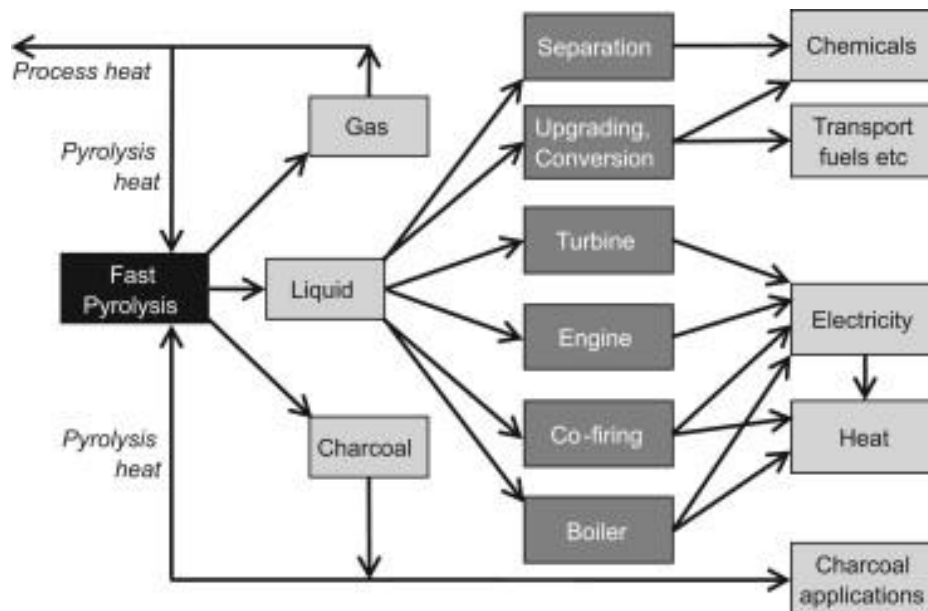
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Pyrolysis



Taken from Meier *et al*, *Renew. Sustain. Energy*
Rev., 2013, 20, 619-641