

Green Chemistry

A celebration of the advances made by Chemistry in producing new environmentally friendly products.

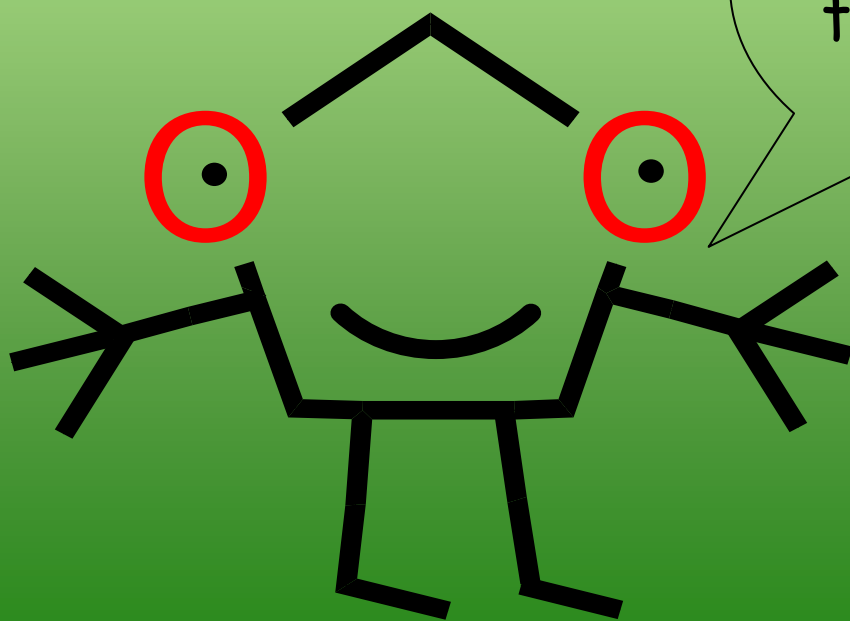


KEELE
UNIVERSITY

RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk
www.makeitmolecular.com

Please make a
selection from
the molecules
shown.



Lactic Acid

Biodiesel

Vanillin

DME

Butanol

TAML

Carbon Dioxide

Tebufenozide

Sea-Nine 211

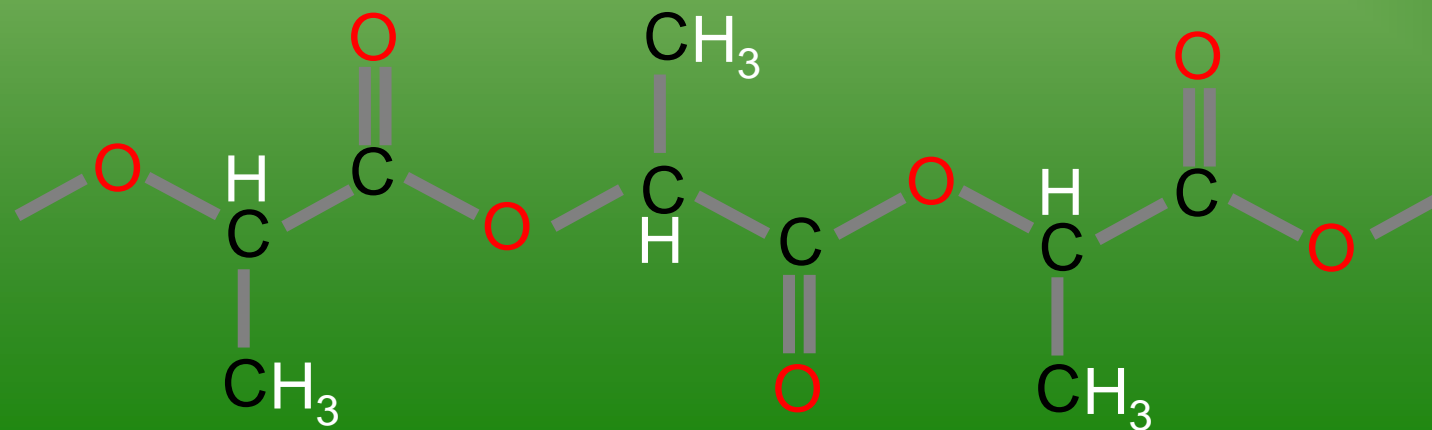
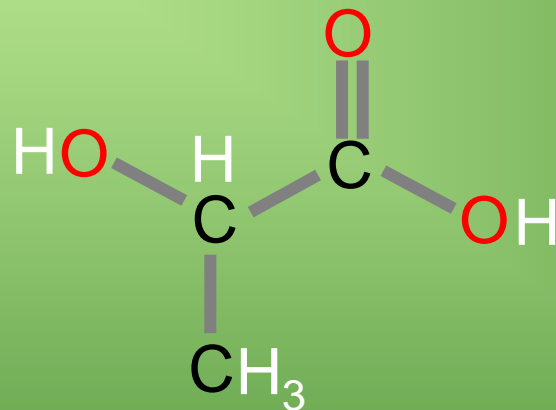
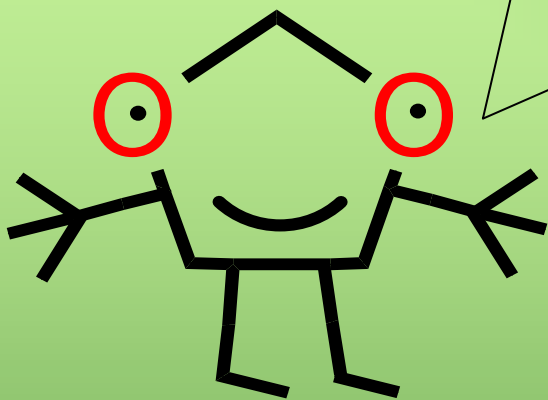
Ibuprofen

Dry Cleaning
surfactants

Vernolic Acid

Lactic Acid

Poly lactide (PLA) is one of the new generation biodegradable thermoplastics made from bacterial fermentation of starch



Atoms and bonds:

3 C Carbon

6 H Hydrogen

3 O Oxygen

4 — short bonds

2 == long bonds



KEELE
UNIVERSITY

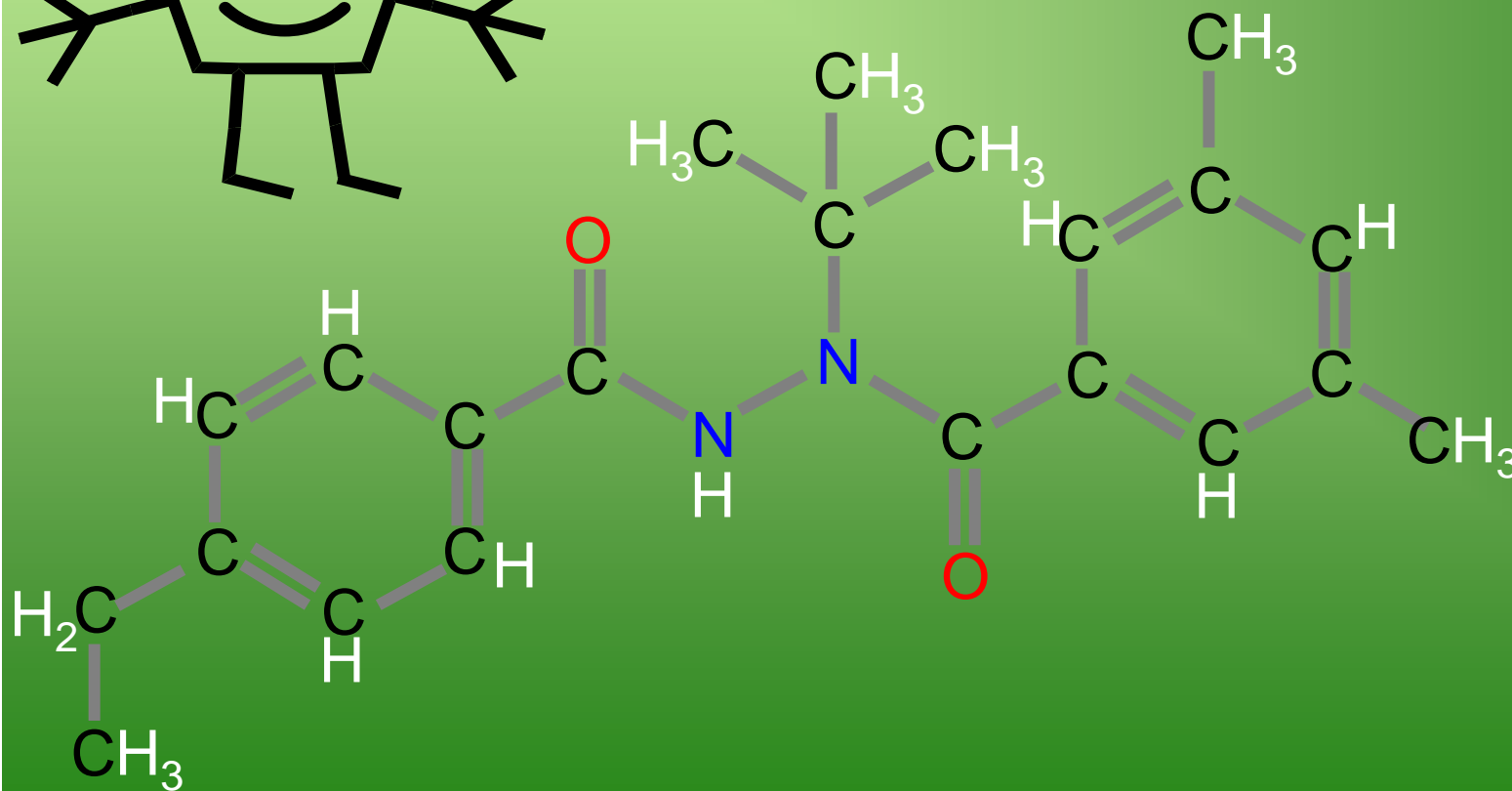
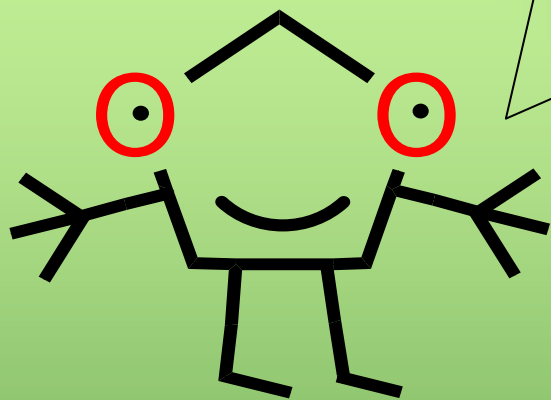
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

Tebufenozide

These insecticides cause a lethal molt in insects, have a very low toxicity in humans and rapidly biodegrade in the environment



Atoms and bonds:

21 C Carbon

28 H Hydrogen

2 O Oxygen

2 N Nitrogen
(dark Blue)

19 — short bonds

16 == long bonds



KEELE
UNIVERSITY

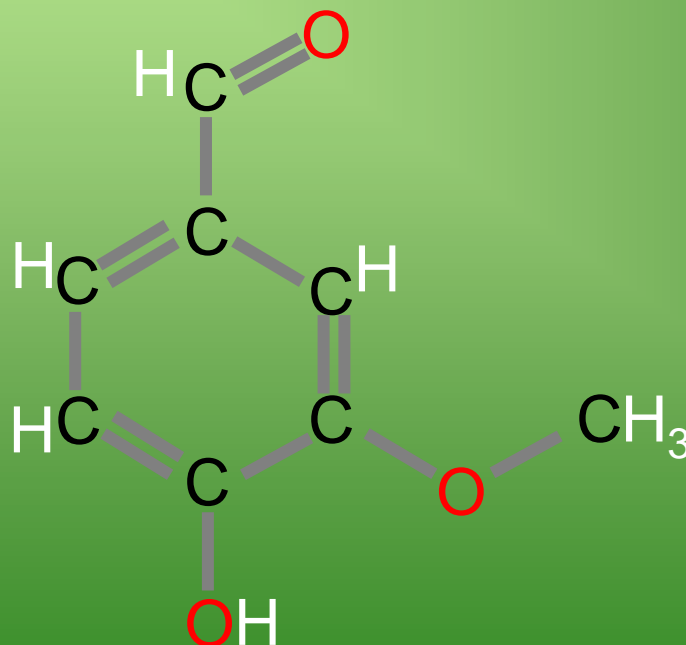
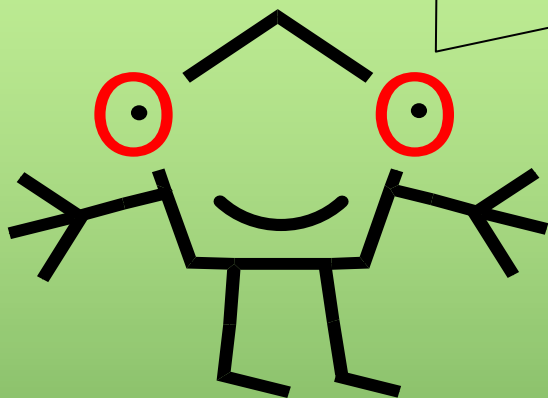
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

Vanillin

This is a feedstock chemical that can be made from wood pulp. It is also the taste of vanilla - a green molecule which tastes good!!



Atoms and bonds:

8 C Carbon

8 H Hydrogen

3 O Oxygen

7 — short bonds

8 == long bonds



KEELE
UNIVERSITY

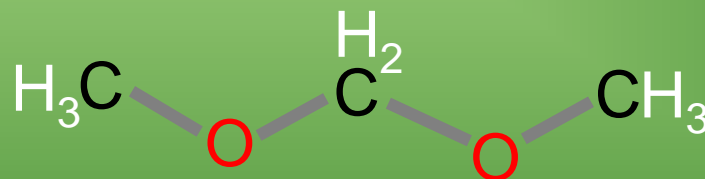
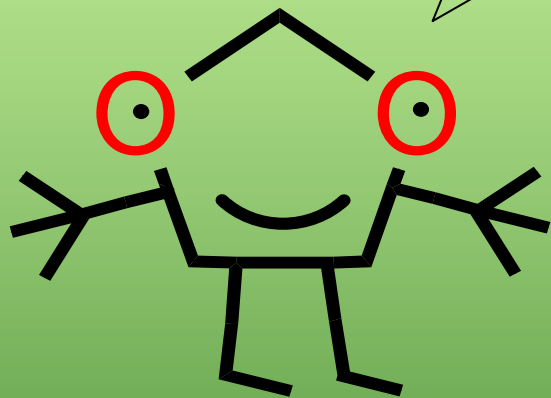
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

DME

Dimethoxy ether is a second generation fuel to replace LPG in engines. It is made by the bacterial breakdown of wood pulp



Atoms and bonds:

3 C Carbon

8 H Hydrogen

2 O Oxygen

4 — short bonds



KEELE
UNIVERSITY

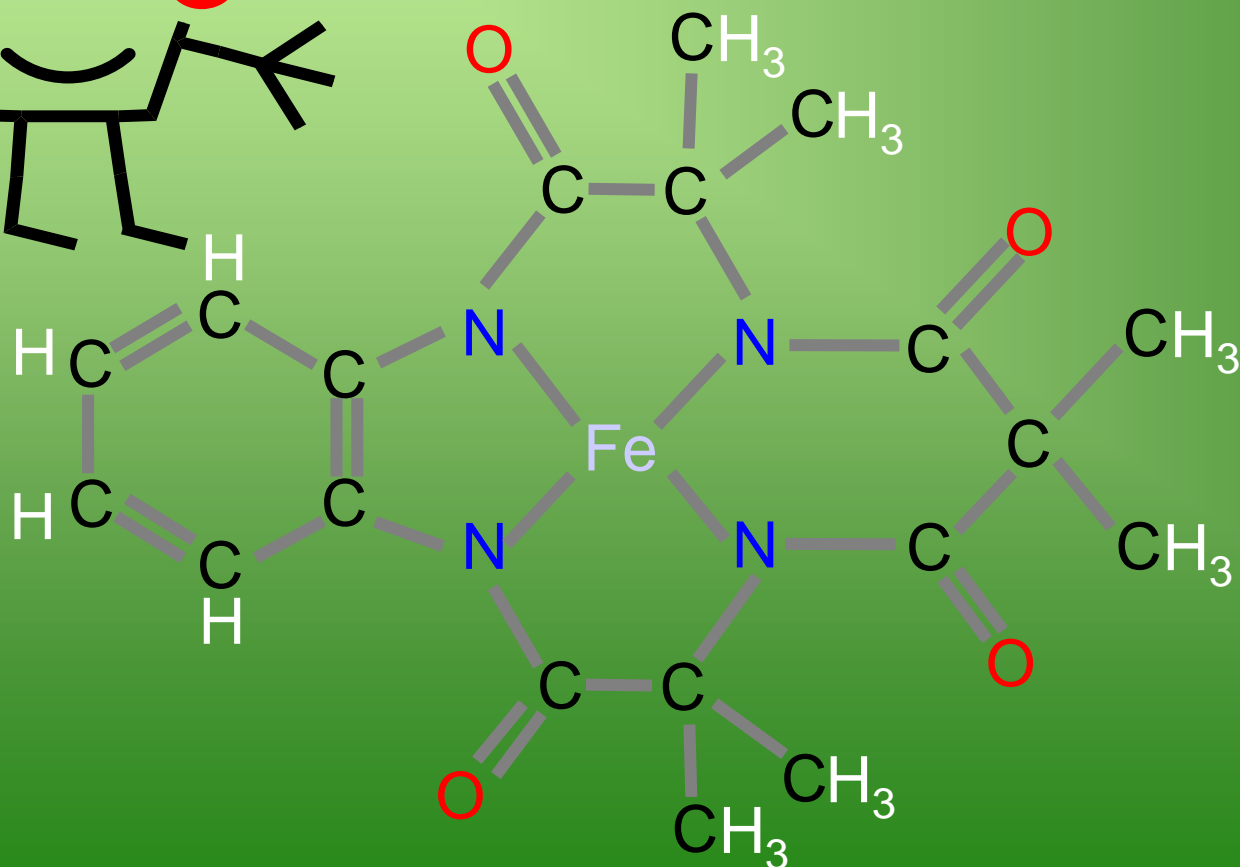
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

TAML

This catalyst is used to activate hydrogen peroxide to produce an environmentally friendly way of bleaching paper



Atoms and bonds:

19 C Carbon

22 H Hydrogen

4 O Oxygen

4 N Nitrogen
(Dark Blue)

1 Fe Iron

25 — short bonds

14 == long bonds



KEELE
UNIVERSITY

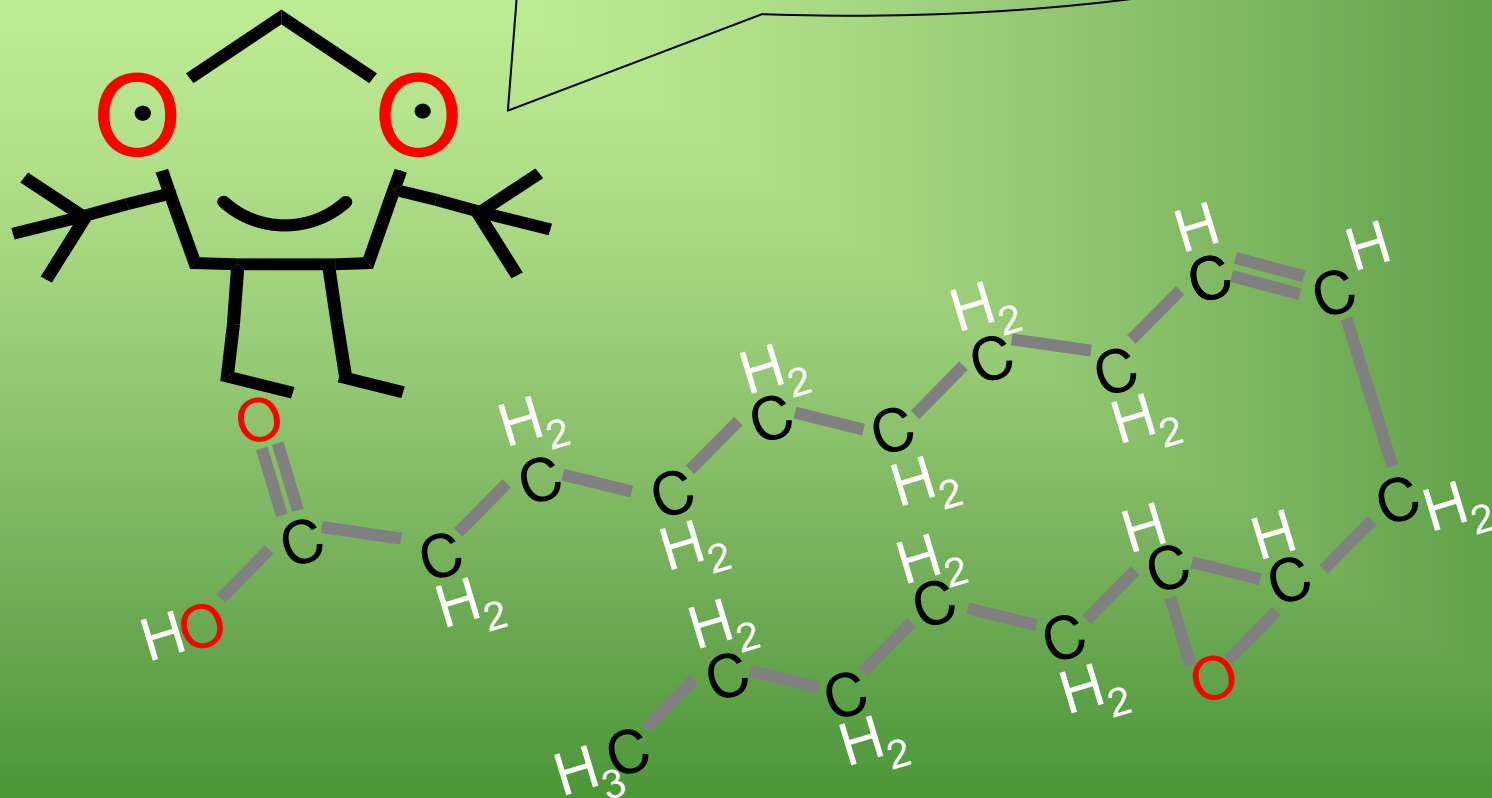
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

Vernolic Acid

Extracted from the seeds of *Vernonia Galamensis*, a plant native to Ethiopia, vernolic acid is being developed to replace the resins in MDF



Atoms and bonds:

18 C Carbon

32 H Hydrogen

3 O Oxygen

19 — short bonds

4 == long bonds



KEELE
UNIVERSITY

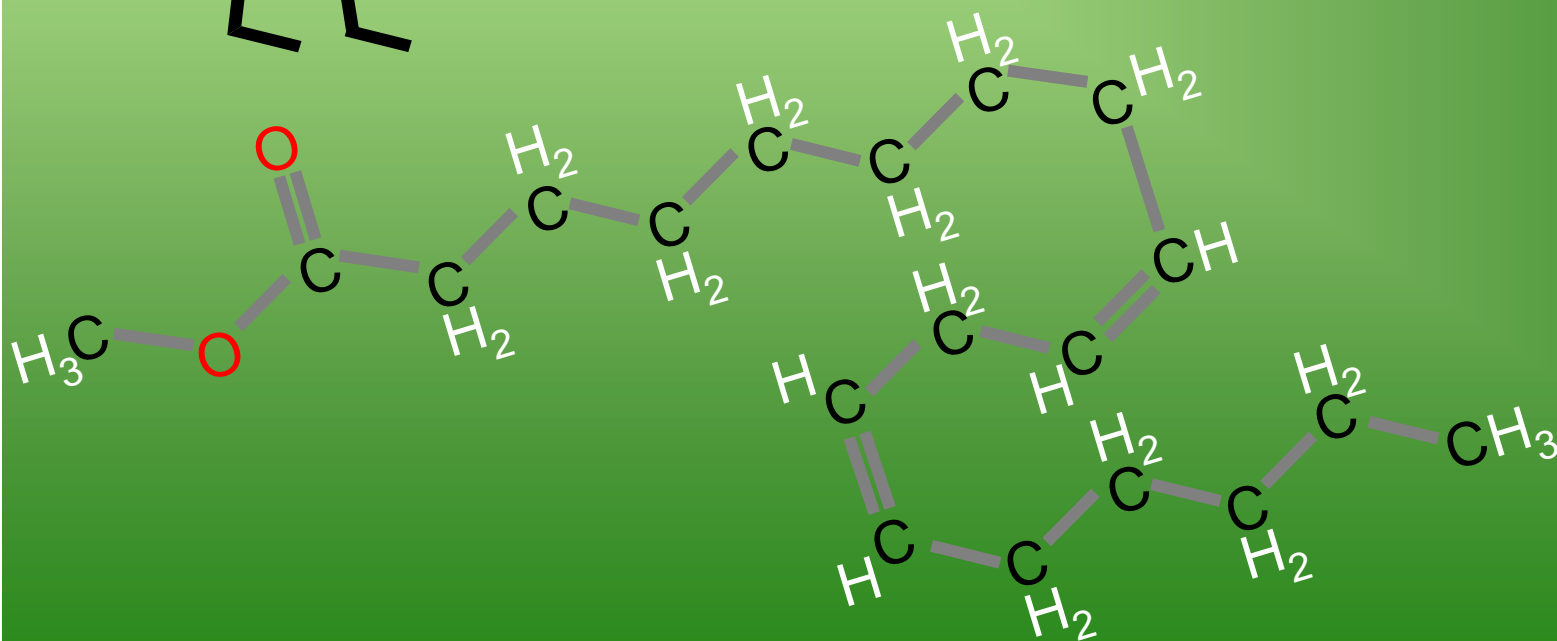
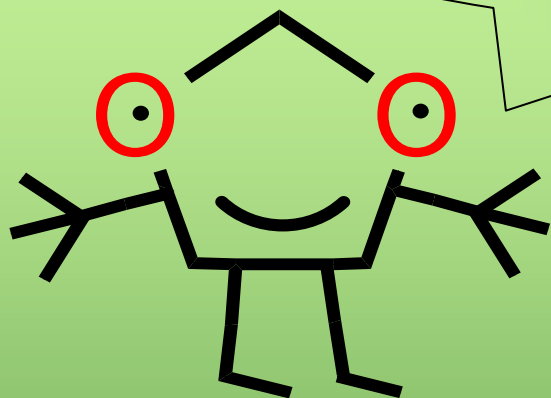
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

Biodiesel

Biodiesel is nothing new, the first diesel engine in 1900 ran on peanut oil. Methyl Linoleate is produced by breaking down soya bean fatty acid triglycerides



Atoms and bonds:

19 C Carbon

34 H Hydrogen

2 O Oxygen

17 — short bonds

6 == long bonds



KEELE
UNIVERSITY

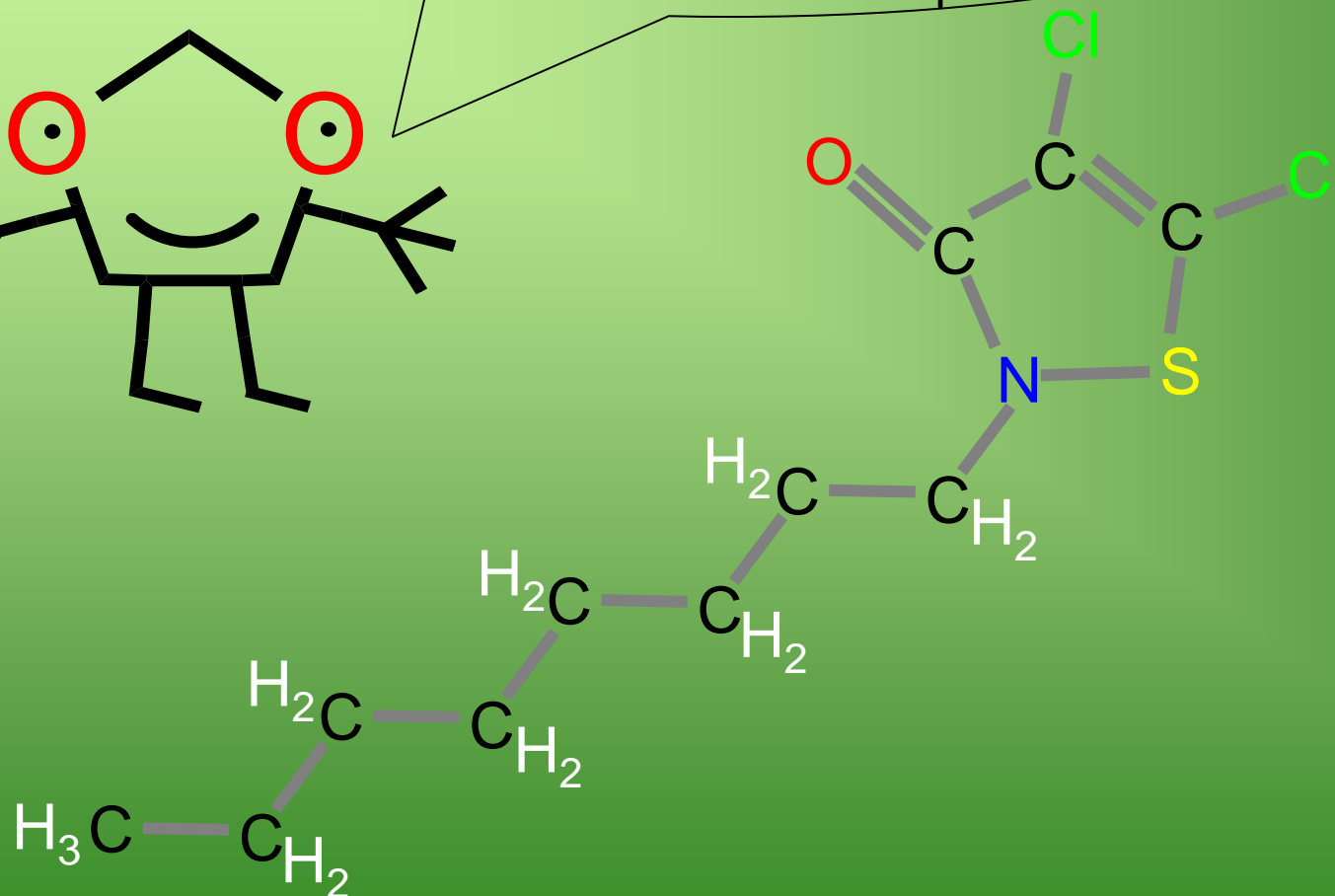
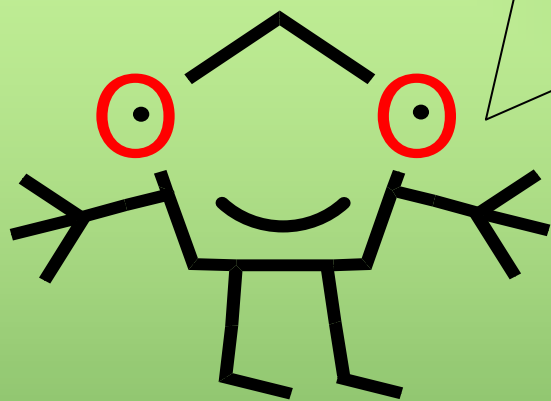
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

Sea-Nine 211

This is an environmentally friendly antifoulant which is used to remove molluscs and other sea creatures from the hulls of ships.



Atoms and bonds:

11 C Carbon

17 H Hydrogen

1 O Oxygen

1 S Sulphur

2 Cl Chlorine

1 N Nitrogen
(Dark Blue)

14 — short bonds

4 == long bonds



KEELE
UNIVERSITY

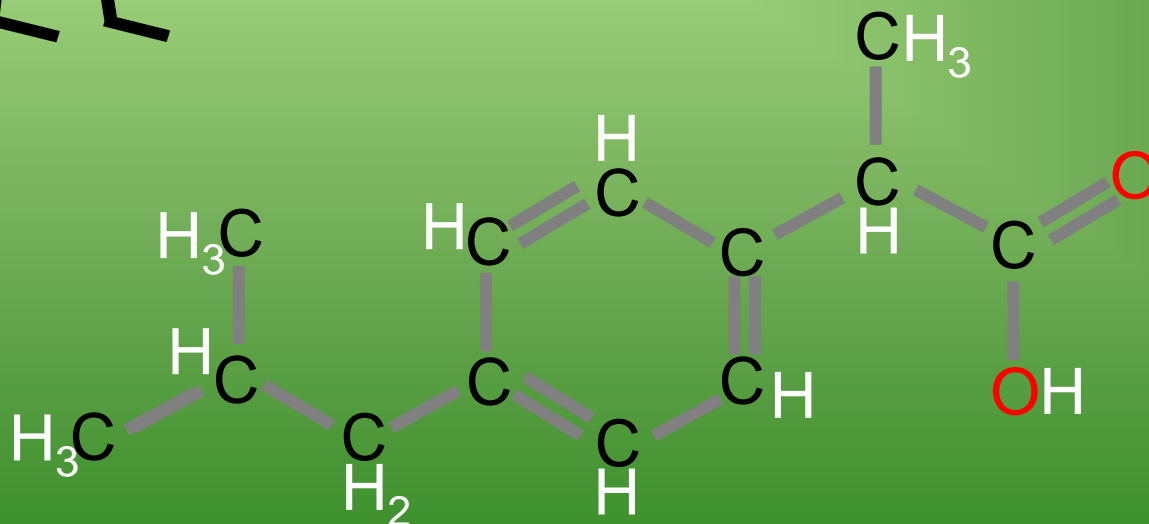
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

Ibuprofen

The BHC synthesis of ibuprofen heralded a new era in drug synthesis, being achieved in 3 steps and with 77% atom efficiency.



Atoms and bonds:

13 C Carbon

18 H Hydrogen

2 O Oxygen

11 — short bonds

8 == long bonds



KEELE
UNIVERSITY

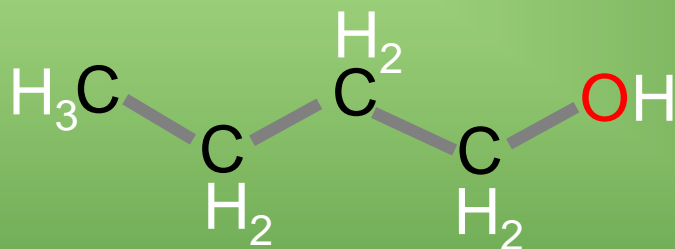
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

Butanol

A biofuel that can be produced by bacteria from wood pulp and can be used directly as a replacement for petrol



Atoms and bonds:

4 C Carbon

10 H Hydrogen

1 O Oxygen

4 — short bonds



KEELE
UNIVERSITY

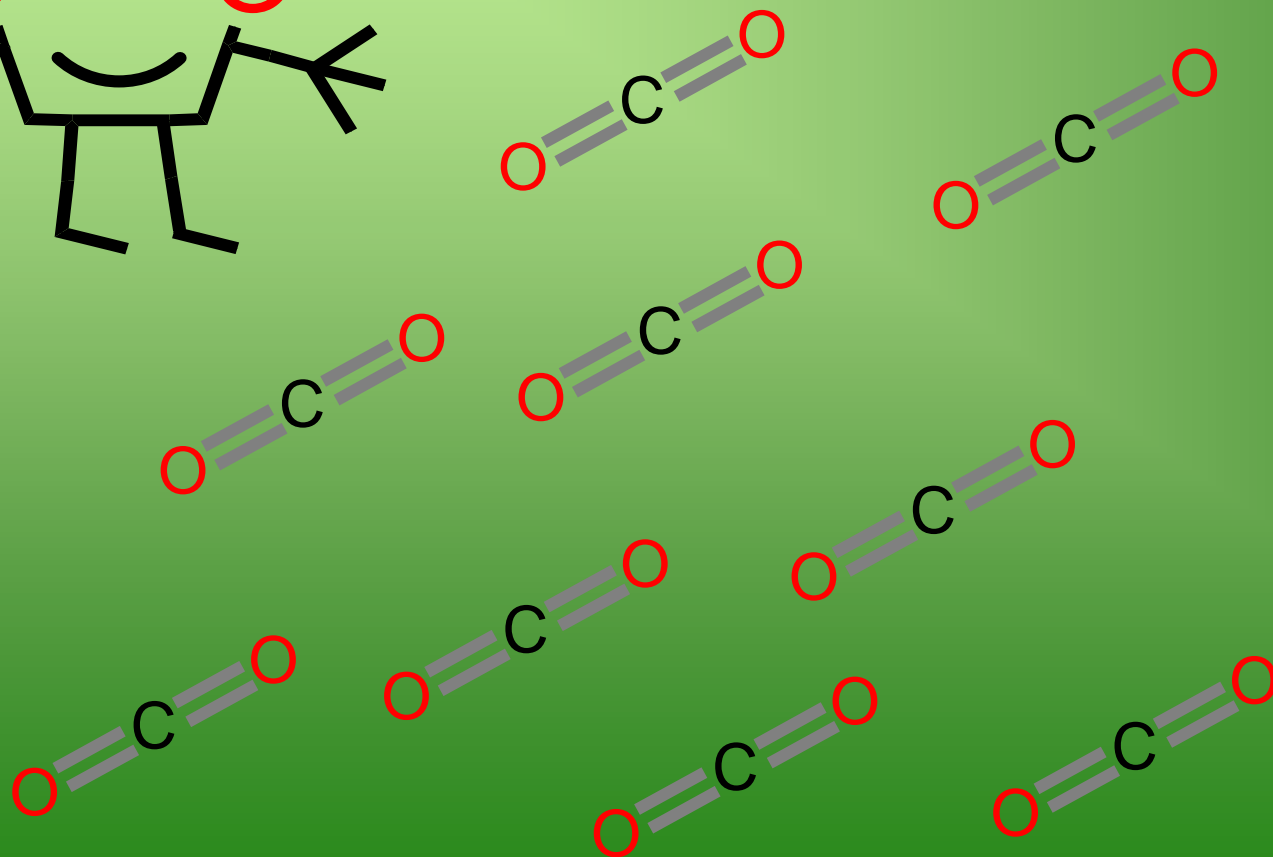
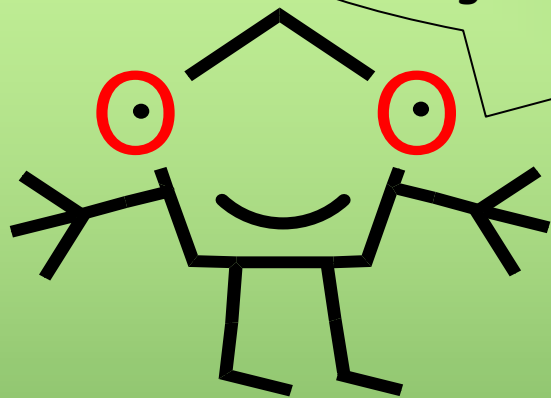
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

Carbon Dioxide

CO₂ is the greenhouse gas we want to stop producing, but itself it has many green uses in refrigeration, dry cleaning and as a solvent for chemical reactions



Atoms and bonds:

1 C Carbon

2 O Oxygen

4 == long bonds



KEELE
UNIVERSITY

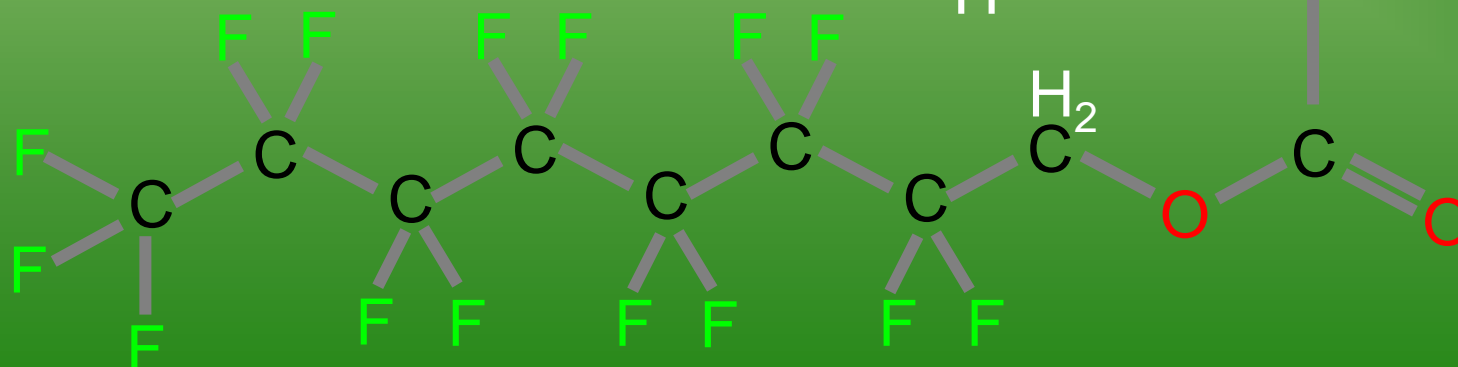
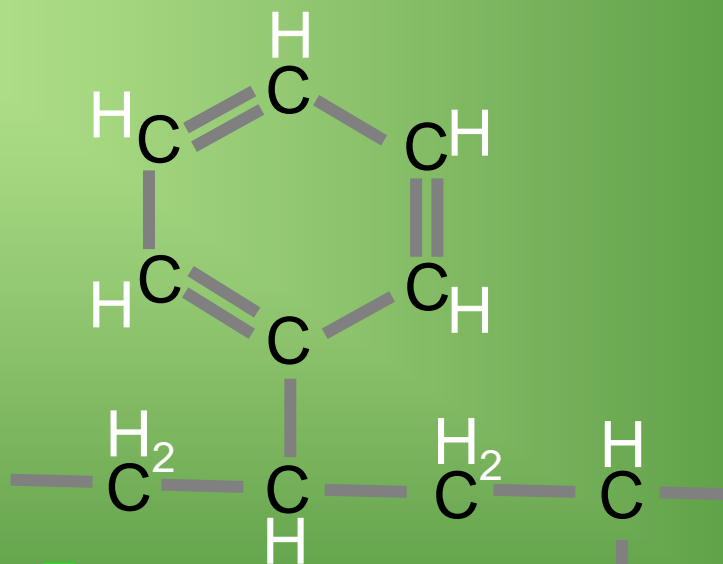
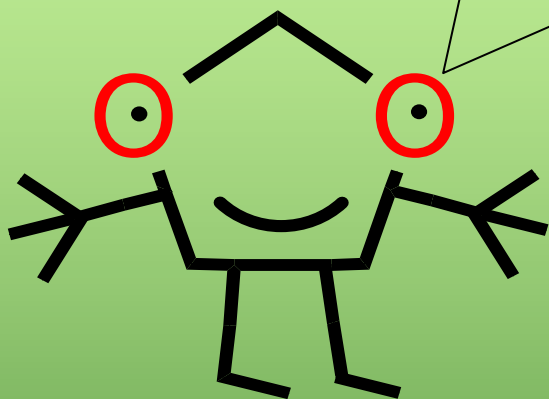
RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com

Dry Cleaning Surfactants

Polymers of these molecules allow CO_2 to be used for dry cleaning replacing ozone depleting CFC's



Atoms and bonds:

19 C Carbon

13 H Hydrogen

2 O Oxygen

15 F Fluorine

34 — short bonds

8 == long bonds



KEELE
UNIVERSITY

RSC | Advancing the
Chemical Sciences

Molly Cool and makeitmolecular designed by
G R Jones, g.r.jones@keele.ac.uk

www.makeitmolecular.com