UNIVERSITY OF CAMBRIDGE

Liquid crystals

Lecture 10

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Course B: Materials for Devices

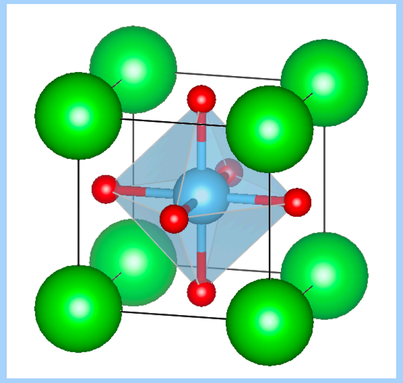
Professor M does Science

http://www.tcm.phy.cam.ac.uk/~bm418/

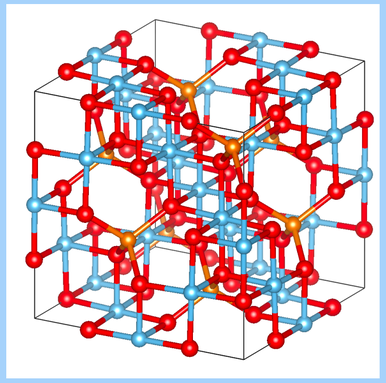
Course B: Materials for Devices

order → disorder

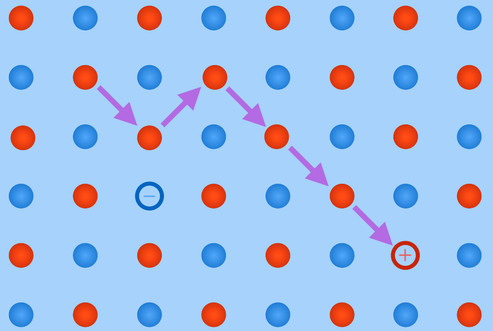
electric polarisation in materials



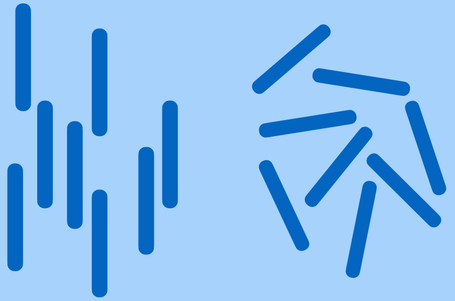
magnetism in materials



ionic conductors



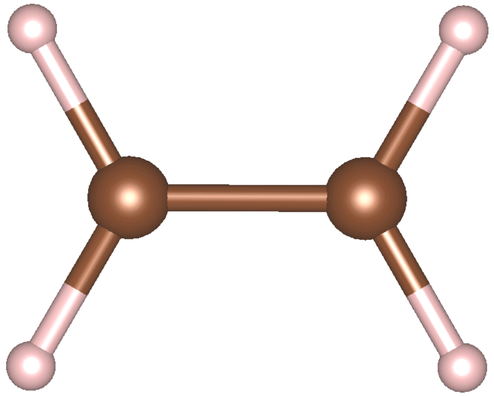
liquid crystals

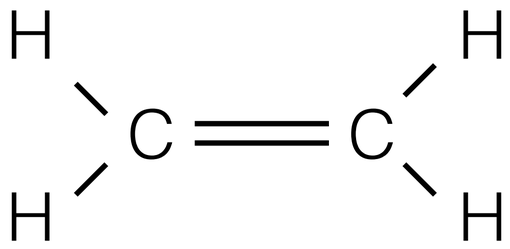


Polymers

- Polymer: material made of large molecules composed of many repeating units
- Monomer: small molecular unit that combines with others to form a polymer

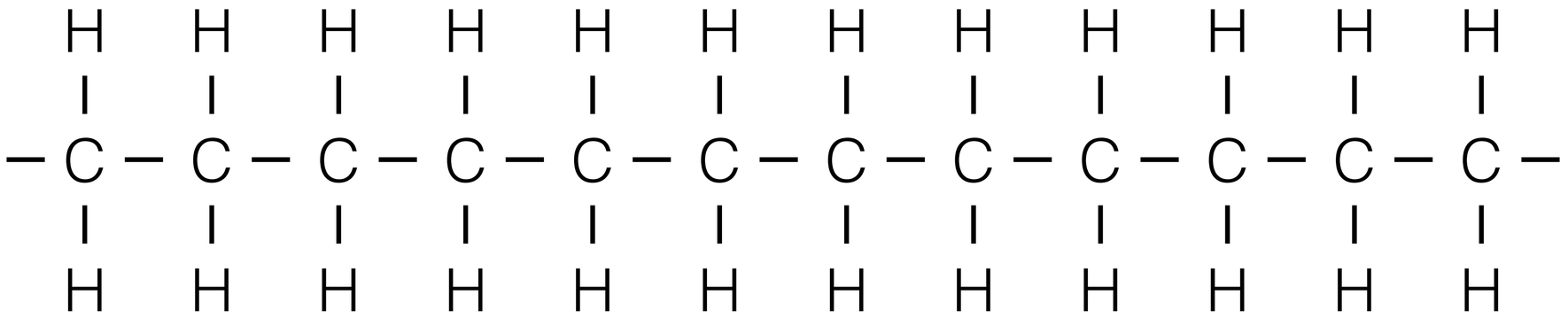
Polymers: polyethylene





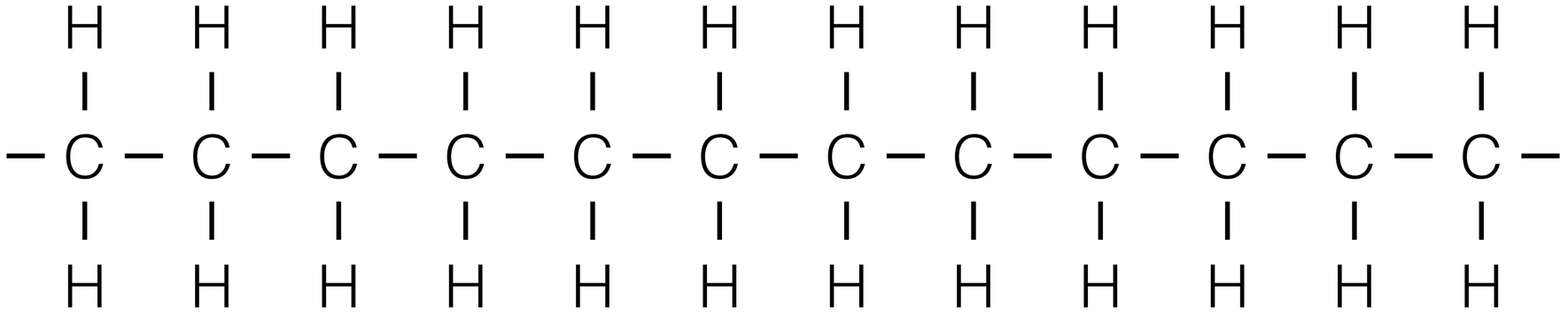
- Ethylene (ethene)
- Planar molecule
- Simplest alkene
- Acts as monomer of polyethylene

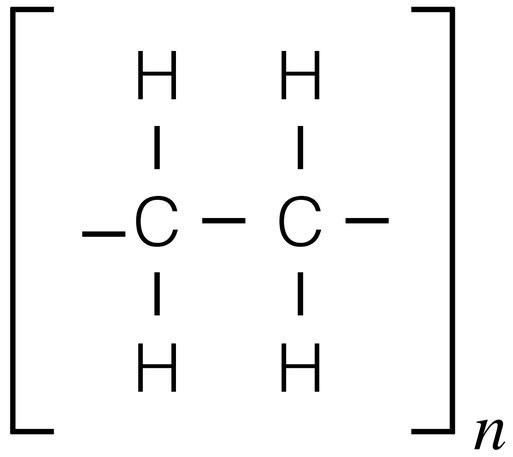
Polymers: polyethylene



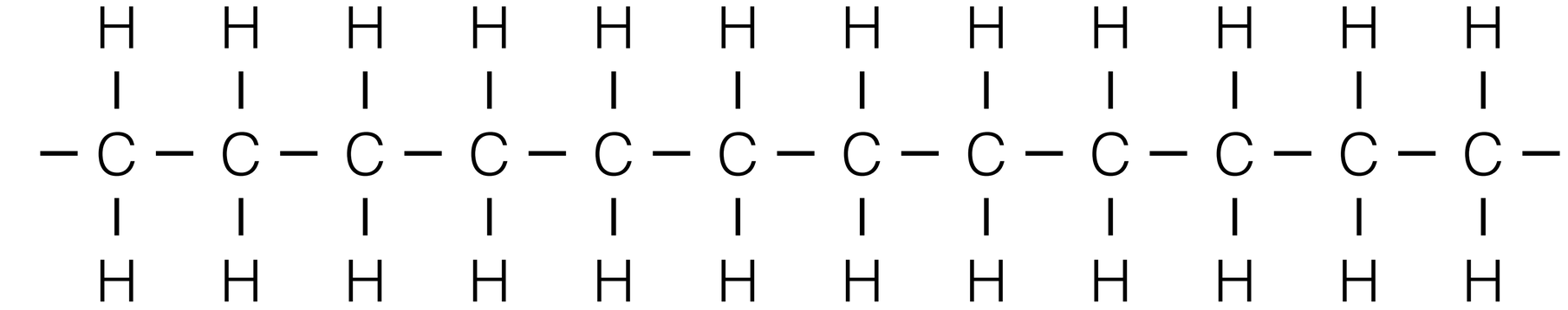
- Polyethylene (polyethene)
- Polymer made by polymerisation of ethylene
- Most commonly produced plastic (e.g. plastic bags, bottles)

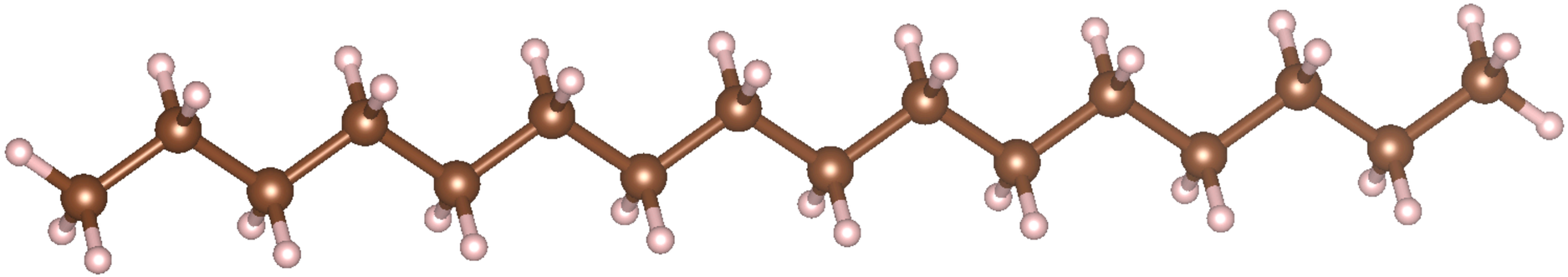
Polymers: polyethylene





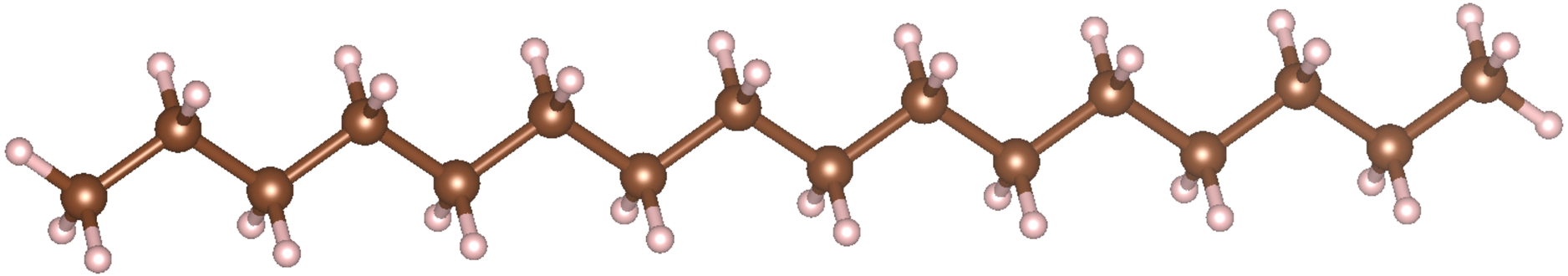
Polymers: polyethylene





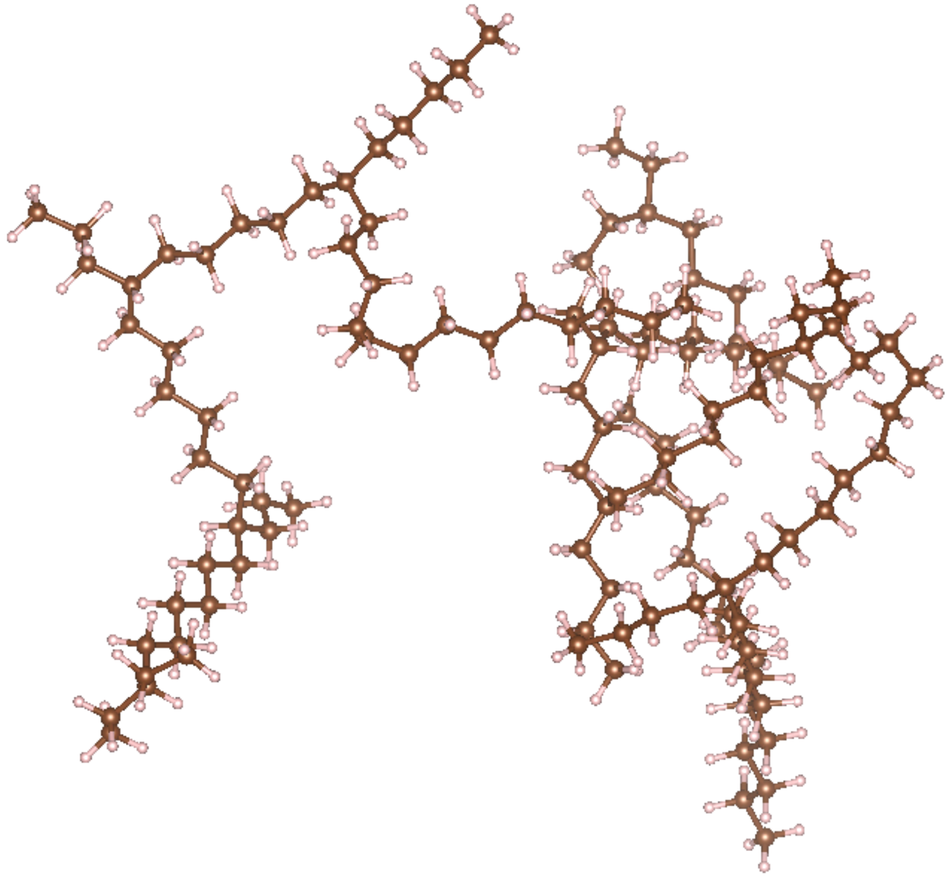
- *See structure model in 3D*

Polymers: polyethylene



- Low-density: trays, plastic bags, car parts, ...
- Medium-density: water plumbing, ...
- High density: plastic bottles, corrosion resistant piping, ...
- Ultra-high molecular weight: fibres, medical implants, ...
- Cross-linked: domestic water plumbing, insulation for high voltage electrical cables, ...
- Linear low-density: plastic bags, toys, lids, ...

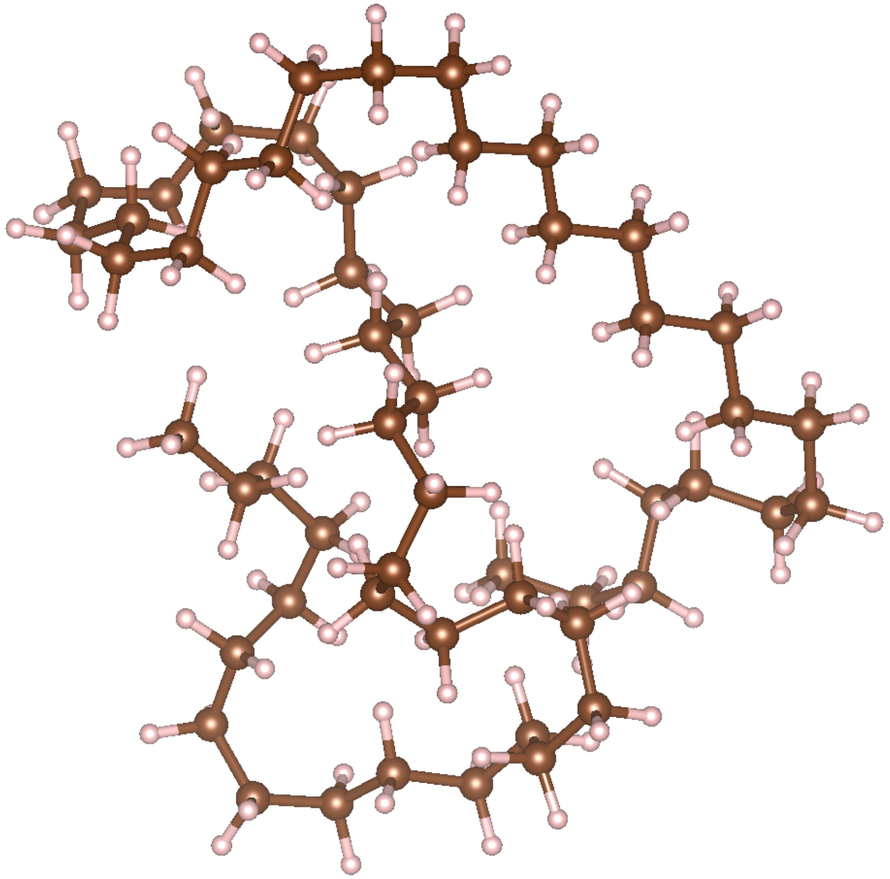
Polymers: polyethylene



- Low-density polyethylene
- Significant branching reducing intermolecular interactions
- Branching suppresses close-packing

- *See structure model in 3D*

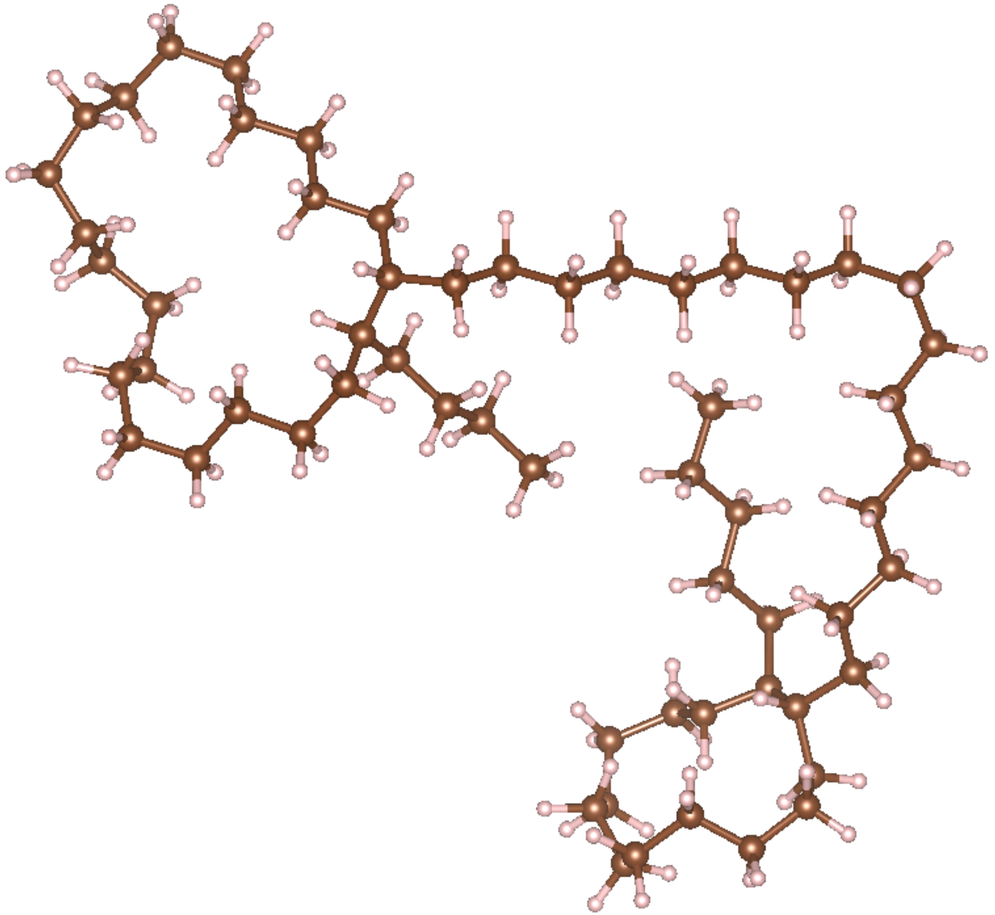
Polymers: polyethylene



- High-density polyethylene
- Single-chain configuration enables close-packing
- High strength-to-density ratio

- *See structure model in 3D*

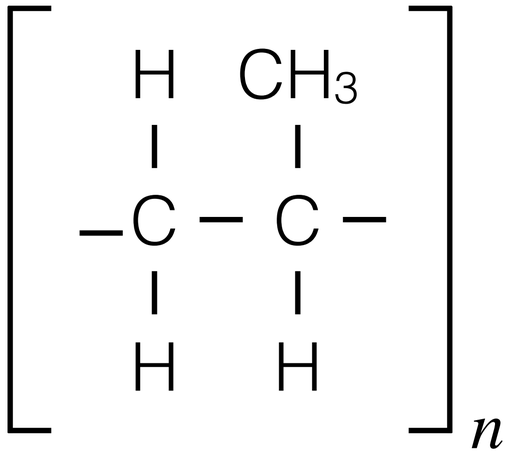
Polymers: polyethylene



- Cross-linked polyethylene
- Stability at high temperature, wear resistance
- Reduced hardness and rigidity

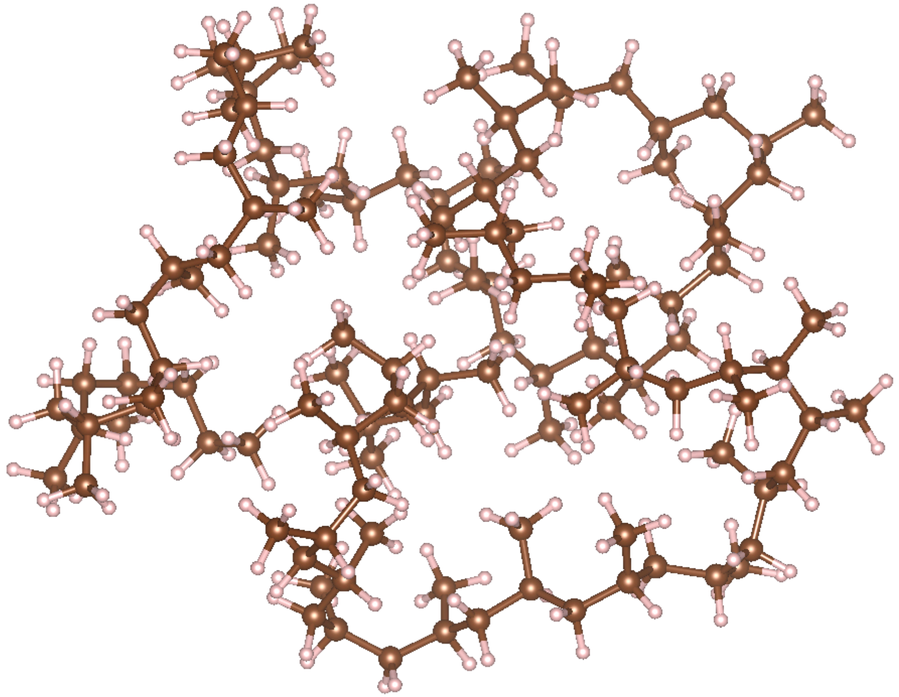
- *See structure model in 3D*

Polymers: polypropylene



- Second most widely produced polymer plastic
- Furniture, lab equipment, clothes, ...

Polymers: polypropylene



- Second most widely produced polymer plastic
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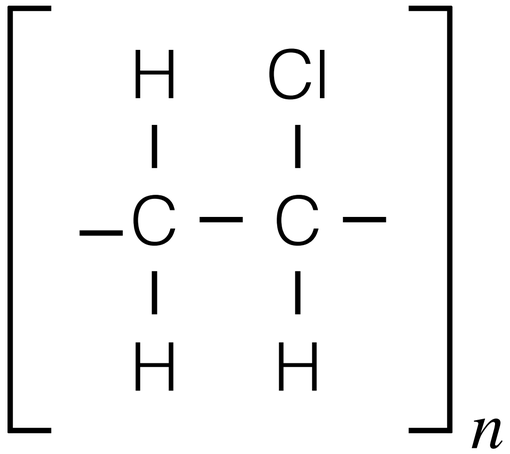
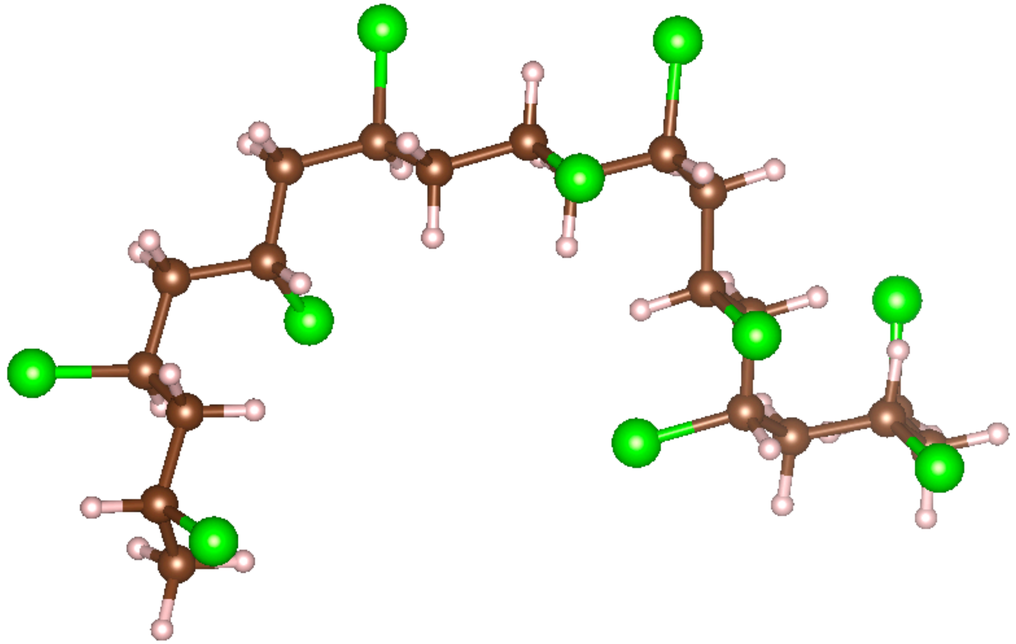
- *See structure model in 3D*

Polymers: polyvinyl chloride (PVC)



- Third most widely produced polymer plastic
- Rigid form: pipes, door and window frames, ...
- Flexible form: electrical cable insulation, flooring, ...

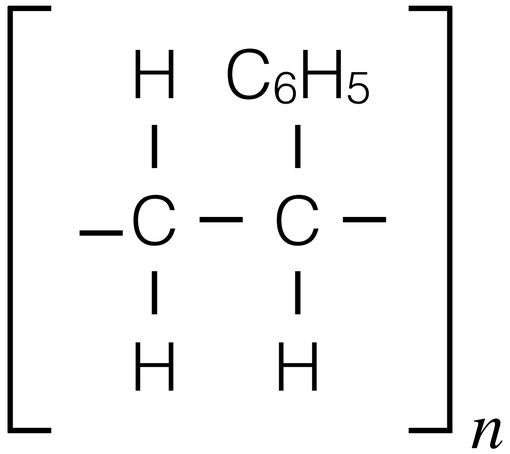
Polymers: polyvinyl chloride (PVC)



- Third most widely produced polymer
- Rigid form: pipes, door and window frames, ...
- Flexible form: electrical cable insulation, flooring, ...

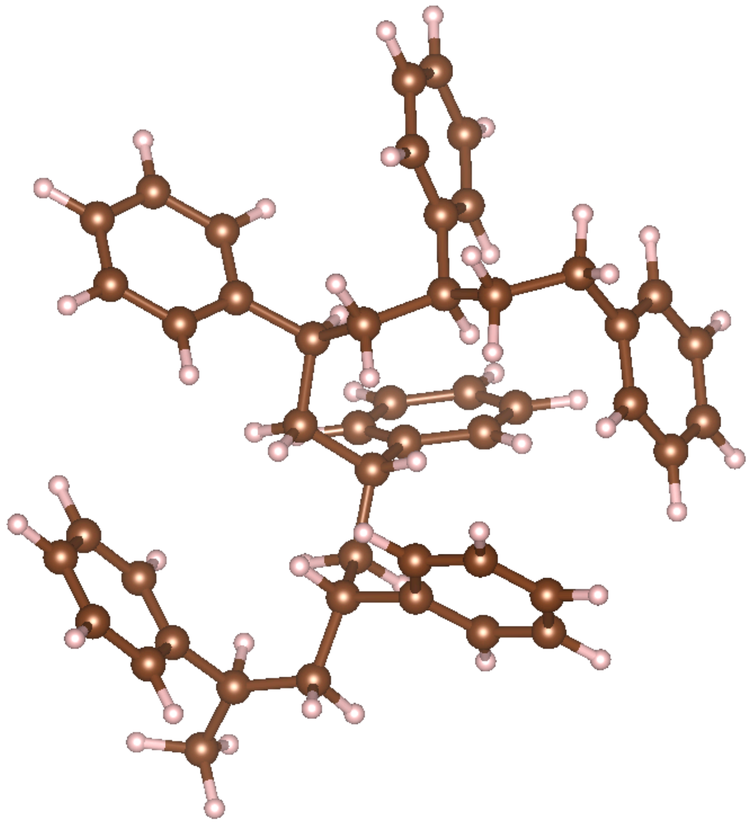
- *See structure model in 3D*

Polymers: polystyrene



- One of the most widely used polymers
- Packaging, bottles, trays, disposable cutlery, ...

Polymers: polystyrene



- One of the most widely used polymers
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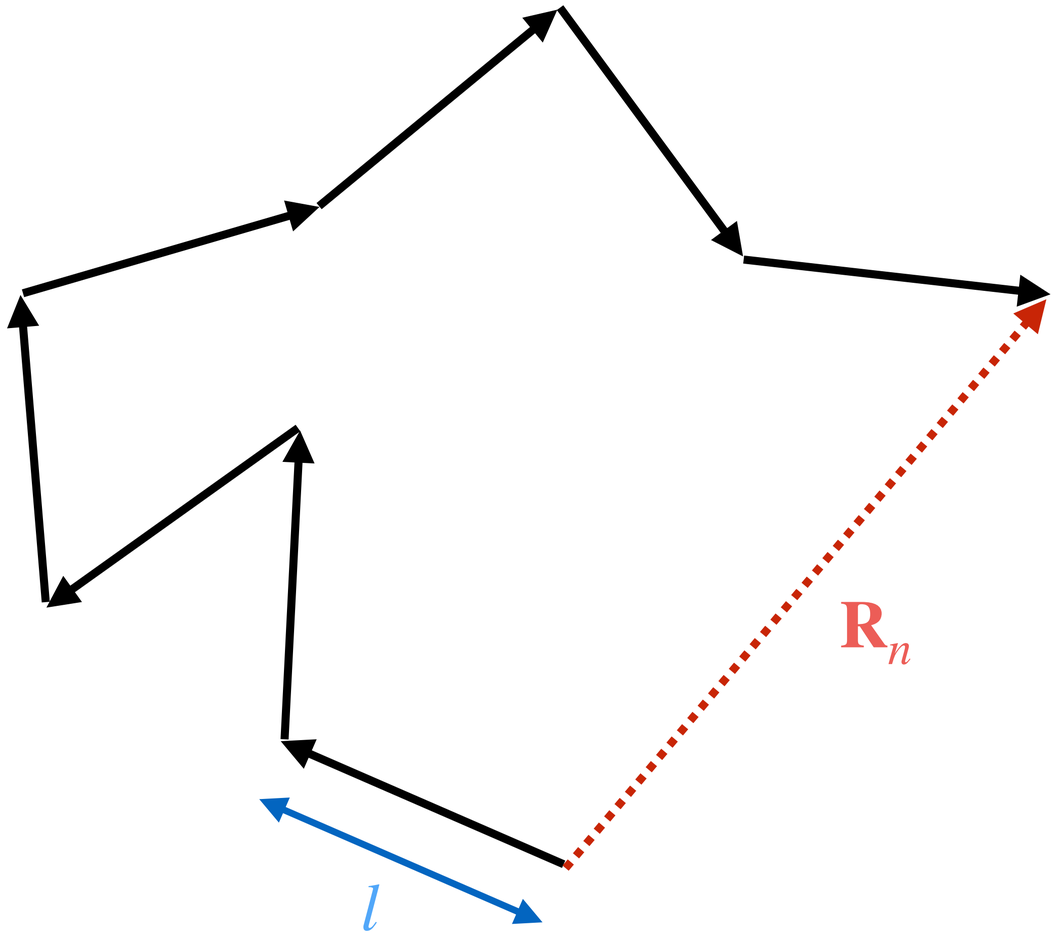
- *See structure model in 3D*

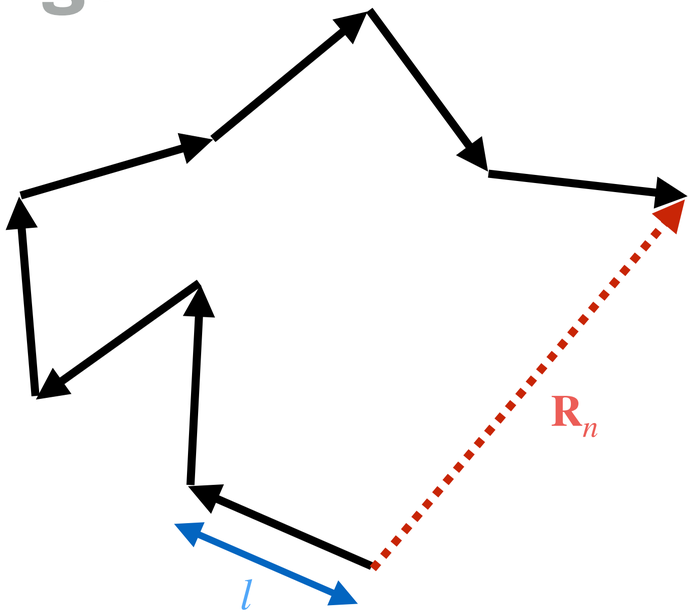
Random walk

- *See derivation of the end-to-end distance*



$$\sqrt{\langle \mathbf{R}_n^2 \rangle} = l\sqrt{n}$$

Kuhn length



$$\sqrt{\langle \mathbf{R}_n^2 \rangle} = l\sqrt{n}$$

- What is the length l in this random walk model of a polymer?
- It is *not* typically the C-C bond length, as the assumption of uncorrelated segments does not apply for C-C bonds
- Kuhn length: the length of a segment of polymer that is uncorrelated to other segments

Kuhn length

Polymer	Number of monomers per Kuhn segment
Polyethylene	5.7
Polypropylene	5.9
Polyvinyl chloride (PVC)	7.6
Polystyrene	10.8