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Part 2 Post-16 – Conducting polymers and shape memory polymers

Teacher 's notes

These are worksheets for post-16 chemistry students.

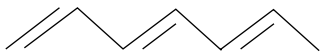
The section *Conducting polymers* uses the new material as a basis for comparing the structures of intrinsically and extrinsically conducting polymers.

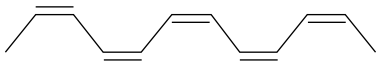
The section *Shape changing polymers* is suitable for use with students who have already studied simple hydrocarbons, and addition polymerisation, and have been introduced to free radical mechanisms, including that for the reaction of methane with bromine. It uses the concepts of thermosetting and thermosoftening plastics to consider polymer formation by both irradiation and chemical reactions.

Answers to questions on conducting polymers

1. Having alternating single and double bonds.

2.

a)  all *trans*- poly(ethyne)

b)  all *cis*- poly(ethyne)

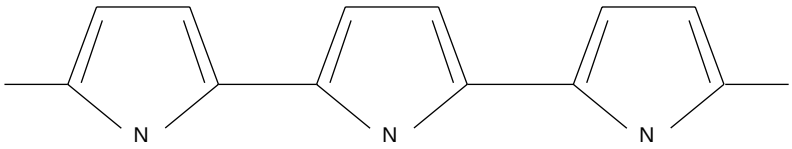
3. An alkene, *not* an alkyne.

4. Because oxygen attacks the electron-rich double bonds in alkenes. Sensible suggestions for products include: epoxy compounds, ozonides, diols and ketones (with the chain breaking).

5. Suggestions might include;

   low density; and

   easy to shape at lower temperatures.

6. 

7. A material composed of a mixture of two or more materials. The composite's properties are derived from those of its constituents.

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8. The conductivity goes down with increasing temperature – *ie* the resistance goes up.

9. Structure a) as it is conjugated.

10. C–C, 0.134 nm; C=C, 0.154 nm; benzene, 0.140 nm. X-ray diffraction to measure the bond lengths.

11. Electrons move through a "sea" (the conduction band) which encompasses the whole metal. This sea is three-dimensional rather than two-dimensional as in graphite and one-dimensional as in poly(ethyne) and can be thought of as a super-delocalised orbital.

Answers to questions on shape memory polymers

1. C–C bonds. This could degrade the polymer by shortening the chains.

2. The polymer might become, in effect, a thermoset. This means it is no longer mouldable.

3. Van der Waals forces. They are typically 1/100 the strength of a covalent bond – a few kJ mol^{-1} compared with about 350 kJ mol^{-1}. The high strength of the plastic is because large numbers of these bonds must be broken to break the material.

4. a) Propagation and termination.

   b) Ultraviolet light does not have enough energy to break C–H bonds. (Typically ultraviolet light has an energy of 400 kJ mol^{-1} compared with 413 kJ mol^{-1} for an average C–H bond). Ultraviolet light has less energy per quantum than β-radiation.

   c) $CH_3^{\bullet} + CH_3^{\bullet} \rightarrow C_2H_6$ as a C–C bond is formed in both cases.

5. *Homolytically* describes the breaking of a covalent bond so that one of the shared electrons goes to each of the atoms in the bond.

   Electronegativity is the ability of an atom to attract electrons to itself in a covalent bond.