**PVC**

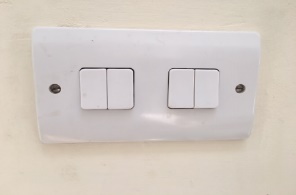
Polyvinyl chloride (PVC) is a polymer.

PVC can be made so that is rigid or flexible.

Flexible PVC is the same as rigid PVC but has plasticiser added.

**Rigid PVC**

**No plasticiser**



**Flexible PVC**

**With plasticiser**



Some students are talking about why adding plasticiser makes PVC flexible.

Who do you agree and disagree with, and why?

**Bailey:** Plasticiser gets in between the long molecules and helps them to slide over each other.

**Aiden:** Plasticiser reacts with the PVC to make a new substance.

**Elliot:** Plasticiser breaks up PVC molecules, so they are shorter.

**Chloe:** Rigid PVC is a polymer that has very long molecules that are fixed in place.

**Demi:** Plasticiser pushes the long molecules apart so the forces holding them together are not as strong.

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| Cards for  **PVC** | **Bailey:** Plasticiser gets in between the long molecules and helps them to slide over each other. |
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*Chemistry > Big idea CMS: Materials science > Topic CMS2: Designing materials > Key concept CMS2.1: Polymer properties*

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| --- |
| **Diagnostic question** |
| **PVC** |

**Overview**

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| Learning focus: | Materials scientists can design polymers with specific properties. |
| Observable learning outcome: | Explain how the addition of plasticisers between molecules can make a polymer softer and more flexible. |
| Question type: | talking heads |
| Key words: | polymer, plasticiser |

**What does the research say?**

One research paper (Cooper et al., 2012) emphasises the importance of the idea that a substance’s molecular structure determines its macroscopic properties

Research (Cooper, Williams and Underwood, 2015) cites research that found that around a quarter of grade 12 (US) students taking part on the study indicated that intermolecular forces occurred within molecules. The authors found in their own student that when asked to draw the location of intermolecular forces some students drew just one molecule.

This question introduces students, at an early stage, to thinking about how a change in the structure of a polymer (by the addition of plasticisers) will affect its properties.

**Ways to use this question**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in each group. For example, you may choose to select a student with strong prior knowledge as the scribe. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**

Demi gives the most scientific answer.

**How to respond - what next?**

A student who agrees with Aiden may have recalled that different substances have different properties. However, in this case the substance (polyvinylchloride) is the same but the plasticiser changes its structure affecting its properties.

Agreement with Elliot suggests that the student does no recognise that rigidity and flexibility will be affected by how strongly the molecules are held together.

Agreement with Bailey shows that a student is thinking along the right lines but may not have formulated a scientific explanation.

Chloe is not incorrect so a student agreeing with Chloe may understand why PVC is rigid but not how plasticisers change this.

If students have misunderstandings about how plasticisers keep the polymer strands more separated (and hence reduce forces between molecules) it may help to draw a visual representation.

The following BEST ‘response activities’ could be used in follow-up to this diagnostic question:

* Explaining plasticisers

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG) and Helen Harden (UYSEG).

Images: Peter Fairhurst (UYSEG)

**References**

Cooper, M. M., et al. (2012). Development and assessment of molecular structure and properties learning progression. *Journal of Chemical Education,* 89(11)**,** 1351-1357.

Cooper, M. M., Williams, L. C. and Underwood, S. M. (2015). Student understanding of intermolecular forces: A multimodal study. *Journal of Chemical Education,* 92**,** 1288-1298.