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The plastic that came out of thin air!

Teachers' notes

Objectives

- To apply knowledge of polymerisation to other situations.
- To learn about the discovery of Teflon®.

Outline

The story of Roy Plunkett and the discovery of Teflon® (polytetrafluoroethene) can be used to show that many things in science were discovered accidentally. This activity illustrates the way in which scientific work may be affected by the context in which it takes place. It is an example of where war influenced the development of a new material, which now has numerous applications.

Teaching topics

This activity is suitable for 14–16 year old students and could be included when teaching about addition polymerisation and the use of polymers.

Look at the student sheets before reading the more detailed teachers' notes.

Background information

Many scientists would have discarded the new gas cylinder, when no gas came out of it, but Roy Plunkett was puzzled and he wanted to find out more. He was convinced that the cylinder was full and he had to prove this to himself. If he had thrown away the cylinder, Teflon® may have not been discovered. Like Plunkett, many scientists are very inquisitive and need to understand what is going on. They will devise experiments and carry out tests until they are satisfied with the result. Sometimes they get carried away and the methods are not always that sensible. Nevertheless, Plunkett, identified a problem with the cylinder and investigated, and in the process discovered a new plastic.

Teflon® is made by DuPont.

Uses of Teflon®

Teflon® is used as a plastic coating. Probably one of the most well known examples of Teflon® coating is that of cooking utensils.

Teflon® is also used to coat many types of fabrics to meet the needs of water repellence and stain protection, without affecting the material's colour or appearance or feel in anyway. Examples are:

- Leisure and sports wear; jackets, mountaineering clothing, suits, ties, raincoats;
- Furnishing fabrics and leather for upholstery, curtains, wall coverings, garden furniture, mattresses, table and bed linens; and
- Overall and work clothes treated with Teflon® protects the workers not only against weather, but also against dirt and pollution, grease, oils, chemical and acid spills.

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Teflon® has many medical applications:

- Pacemakers
- Artificial corneas
- Substitute bones for chin, nose, skull, hip
- Ear parts
- Trachea replacements
- Heart valves
- Dentures

Space applications:

- Outer skin of space suits
- Fuel tanks for space vehicles
- Heat shields on space ships
- Insulating materials for electrical cables.

The uses of Teflon® are closely related to its properties *ie* it is inert, temperature resistant *etc*. It was because of its chemical inertness that it was used in the atomic bomb for valves and gaskets. If it had not been for this, Teflon® would probably not have been manufactured on a commercial scale because it was so expensive. It was only the necessities of war that allowed Teflon® to be manufactured and developed.

Environmental impact
Polytetrafluoroethene (Teflon®) contains carbon and fluorine only, unlike chlorofluorocarbons (CFCs) where it is the presence of the chlorine atom that allows reaction with ozone (O_3) and has the effect on the ozone layer. When disposed of in landfill or in an incineration plant, fabrics treated with Teflon® decompose slowly and make a negligible difference to the total environmental impact.

Teaching tips

This activity can be used as a stand-alone activity or it can be used as homework after a short introduction to put it into context. It is intended that this activity will be used as a follow-up to addition polymerisation of alkenes or revision. It does not give enough information to answer all the questions, without some previous knowledge of unsaturated molecules, double bonds and polymerisation. However, it can be used to promote some useful discussion of the concepts covered as well as the wider issue of factors that influence the development of science.

Resources

- Student worksheets
  – The plastic that came out of thin air!

Timing

40 minutes

Opportunities for key skills

Information handling – finding out what Telfon® is used for today.

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Answers

1. 6/4/1938

2. He was developing refrigerants.

3. **a)** Tetrafluoroethene
b) C_2F_4
c) Unsaturated

4. The cylinder was heavy, implying it was full. The needle on the pressure gauge pointed to the full position.

5. The valve was broken.

6. The weight of the cylinder still implied that it was full. The valve was not broken and so the pressure reading was correct. Therefore there must be something inside the cylinder. He was curious.

7. He cut the cylinder in half. The cylinder could have exploded because it should have contained gases under pressure.

8. A white solid.

9. Teflon®

10. The small gaseous tetrafluoroethene molecules much have reacted together to make a large polymer. The combination of the gas being kept under pressure and the surface of the metal cylinder to act as a catalyst may have forced the reaction.

11. Polymerisation

12. There are various things he could have done, such as heat C_2F_4 in the presence of different metals or pressurised the gas in the presence of different metals. He would have tried different conditions until he got a good yield.

13. Standard physical and chemical tests would have been carried out, such as solubility in different solvents, resistant to heat and different chemicals, strength tests *etc.*

14. See Teachers' notes.

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Re-enactment of the 1938 discovery of Teflon®
Left to right, Jack Rebok, Robert McHarness and Roy Plunkett
(Reproduced courtesy of the Hagley Museum and Library.)

World War II puts Teflon® on the world market

In 1938, Teflon® with its unreactive properties was very expensive to produce and was in danger of being forgotten. But General Leslie R. Grooves of the US Army heard about Teflon® and commanded it to be manufactured whatever the cost. Teflon® was used to make gaskets and valves to hold corrosive uranium compounds in the atom bomb.

It wasn't until 1960 that the public was introduced to non-stick frying pans!

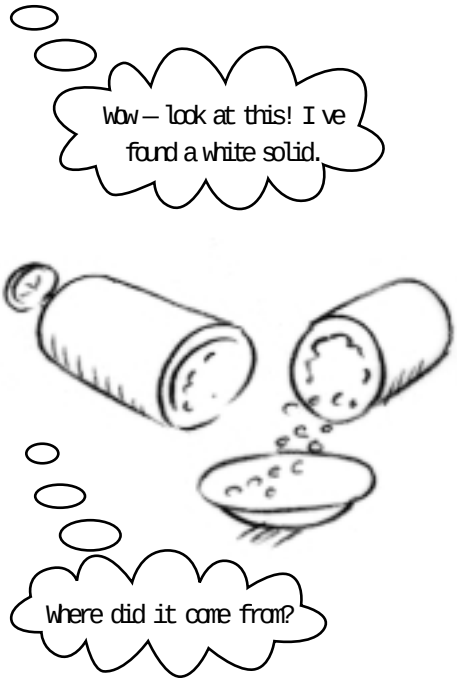
Roy Plunkett accidentally discovers Teflon

6/4/1938

Refrigerants Work

Jobs to do:

1. Get a new cylinder of tetrafluoroethene gas.
2. Clean out equipment.



6/4/1938

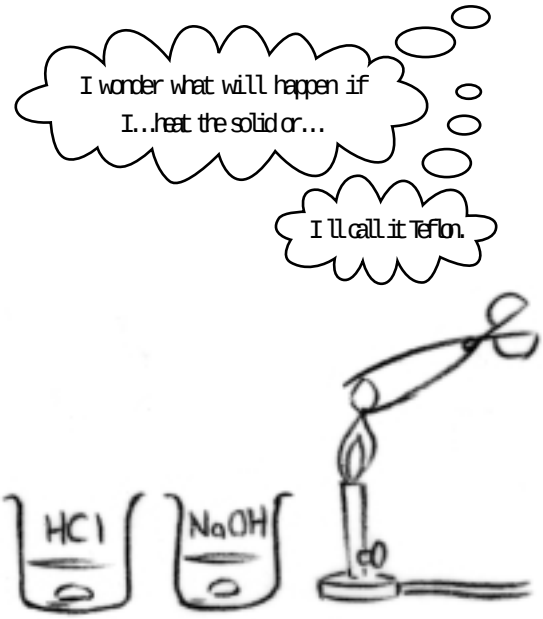
Conclusions about the cylinder.

The small gaseous particles must have reacted together to make this solid.

There wasn't anything else there.

7/4/1938

1. Try to reproduce the white solid in the lab.



Read the cartoon and then answer the following questions.

1. What was the date?

2. What project was Roy Plunkett working on?

3. (a) Name the gas he was going to use.
(b) Write down its formula.
(c) Is this molecule saturated or unsaturated?

4. Give two reasons why Plunkett was surprised when no gas came out of the cylinder?

5. What did he think the problem was?

6. Why do you think he didn't just go and get another cylinder of gas?

7. What did he do next and what risk was involved?

8. What did he find inside the cylinder?

9. What did he call the new material?

10. What did Roy Plunkett think had happened to the original gas in the cylinder?

11. The new material was a plastic. Which of the following processes are used to make plastics a) cracking b) polymerisation c) fractional distillation?

12. The next day Roy Plunkett tried to make the new material in the lab. How do you think he would have done it?

13. Suggest three tests that Roy Plunkett may have carried out on the new material in order to test its properties.

14. If you have time find out what Teflon® is used for today.