

**Stage 6 Chemistry – Module 7**

Teacher lesson plan - Make a membrane model

**Inquiry question:** What are the properties and uses of polymers?

- model and compare the structure, properties and uses of polymers

Time: 45 - 60 min

**Outcomes**

- analyses and evaluates primary and secondary data and information CH11/12-5
- communicates scientific understanding using suitable language and terminology for a specific audience or purpose CH11/12-7

**Working scientifically**

- Questioning and Predicting CH11/12-1
- Conducting Investigations CH11/12-3
- Communicating CH11/12-7

**Syllabus content**

- Students focus on the principles and applications of chemical synthesis in the field of organic chemistry.
- Current and future applications of chemistry – to meet the needs of society.
- Understanding of the properties of materials – including strength, density and biodegradability – and relate these to synthetic polymers.

**Sydney Water aim for activity**

This activity is designed to complement our Chemistry Depth Study - Water recycling excursion program. During the excursion students will see how St Marys Advanced Water Recycling Plant operates first-hand. This lesson can be used as secondary research. Students will investigate how we use polymers in reverse osmosis membranes to filter water and protect the environment.

**Teaching and learning****Introduction**

**Q.** Have you ever wondered what happens to water after you flush the toilet, wash your hands or take a shower?

**A.** Wastewater is 99% water. The remaining one per cent is made up of things you've added to water as you've used it. Sydney Water takes this water and treats it to make it safe to discharge into the environment or re-use as recycled water. See our Wastewater treatment and St Marys Water Recycling Plant webpages for more information.

**Q.** Have you used ultra-pure water in the lab, such as deionised water without minerals and salts? How do we get rid of tiny materials like dissolved nutrients, salts and minerals?

**A.** One way is to distil water- evaporate and recollect the clean water. Another way is to use a physical barrier filter, like a membrane.

**Q.** What are some things to consider if we want to do this on a large scale, for millions of litres of water?

**A.** How much energy it takes, the cost of the equipment to buy and operate, potential problems like scaling or membranes becoming blocked.

**Q.** Have you heard of reverse osmosis?

**Resources****Sydney Water resources**

[Wastewater treatment](#)

[St Marys Water Recycling Plant](#)

[St Marys Advanced Water Recycling Plant](#)

[Wollongong Water Recycling Plant](#)

**Other resources**

[Sydney Desalination Plant](#)

| <p><b>A.</b> Students may say that they've heard of osmosis in biology. They may have used reverse osmosis in a lab or as a home water filter. They may know about desalination. Sydney Desalination Plant can provide Sydney Water with up to 15% of drinking water from seawater. See the Sydney Desalination Plant webpage for more information.</p> <p><b>Q.</b> How do you think this works? How can we use a membrane to remove dissolved nutrients, salts and tiny particles?</p> <p><b>A.</b> That's what we'll be learning in the lesson today. We'll focus on how St Marys Advanced Water Recycling Plant treats 60 million litres of water every day!</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                |                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                            |               |                |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |                     |               |  |               |                 |     |  |                |                          |                      |  |             |            |        |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
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| <p><b>Body</b></p> <p>Go to our High School webpage under HSC Chemistry for fact sheets and activity instructions. Gather the materials needed prior to class.</p> <p>Students can follow the instructions under the 'Make a reverse osmosis membrane model' in the fact sheets and activities tab.</p> <ol style="list-style-type: none"><li>1. Read the content on reverse osmosis membranes.</li><li>2. Build their reverse osmosis models.</li><li>3. Watch the video and factsheet links on the sheet. Students may need to pause and re-watch the video to understand the structure.</li><li>4. Using the information on our factsheets and their own internet search, fill in the research task table. Sample answers below.</li></ol> <table><tr><th>Items in the model</th><th>What do these items represent?</th><th>What polymers are used in the RO module?</th><th>Identify properties that these polymers have. Describe why they were used.</th></tr><tr><td>Clear plastic</td><td>Membrane layer</td><td>Polyamide<br/>Polysulfone<br/>Polyester</td><td>See <i>Polymers in reverse osmosis membranes</i> factsheet.<br/>A quick internet search can give them physical and chemical properties of these polymers. For example, polypropylene is non-polar and hard, great for a permeate tube. Water won't stick to the material making it easier to transport and the tube can withstand pressure. They should relate properties of the polymer to why they were used for specific items/purpose. Think why we used that polymer for that layer or part of the filter.</td></tr><tr><td>Plastic mesh</td><td>Feed channel spacer</td><td>Polypropylene</td><td></td></tr><tr><td>Black plastic</td><td>Permeate spacer</td><td>PET</td><td></td></tr><tr><td>Cardboard tube</td><td>Permeate collection tube</td><td>PVC or Polypropylene</td><td></td></tr><tr><td>Rubber band</td><td>Brine seal</td><td>Rubber</td><td></td></tr></table> <p><b>Q.</b> Do you think we can use reverse osmosis water any other way in Sydney?</p> <p><b>A.</b> We currently use reverse osmosis to produce high-quality recycled water. This can be used as an alternative source of water for environmental flows to natural waterways. It can also be used in industry like steel manufacturing. See St Marys Advanced Water Recycling Plant and Wollongong Water Recycling Plant to read about recycled water end-use. Also see AWA Water recycling facts sheet about recycled water use in Australia, and PUB Singapore website as a comparative study in recycled water use.</p> | Items in the model             | What do these items represent?           | What polymers are used in the RO module?                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Identify properties that these polymers have. Describe why they were used. | Clear plastic | Membrane layer | Polyamide<br>Polysulfone<br>Polyester | See <i>Polymers in reverse osmosis membranes</i> factsheet.<br>A quick internet search can give them physical and chemical properties of these polymers. For example, polypropylene is non-polar and hard, great for a permeate tube. Water won't stick to the material making it easier to transport and the tube can withstand pressure. They should relate properties of the polymer to why they were used for specific items/purpose. Think why we used that polymer for that layer or part of the filter. | Plastic mesh | Feed channel spacer | Polypropylene |  | Black plastic | Permeate spacer | PET |  | Cardboard tube | Permeate collection tube | PVC or Polypropylene |  | Rubber band | Brine seal | Rubber |  | <p><b>Sydney Water resources</b></p> <p><a href="#">High School</a> see in HSC Chemistry<br/><i>Make a membrane model factsheet</i><br/><i>Polymers in reverse osmosis membranes factsheet</i></p> <p><a href="#">The osmosis principle</a> video</p> <p><a href="#">How does reverse osmosis work?</a> video</p> <p><a href="#">St Marys Water Recycling Plant</a></p> <p><b>Other resources</b></p> <p><a href="#">Singapore's National Water Agency</a></p> <p><a href="#">AWA - Water Recycling Fact Sheet</a></p> |
| Items in the model                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | What do these items represent? | What polymers are used in the RO module? | Identify properties that these polymers have. Describe why they were used.                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                            |               |                |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |                     |               |  |               |                 |     |  |                |                          |                      |  |             |            |        |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Clear plastic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Membrane layer                 | Polyamide<br>Polysulfone<br>Polyester    | See <i>Polymers in reverse osmosis membranes</i> factsheet.<br>A quick internet search can give them physical and chemical properties of these polymers. For example, polypropylene is non-polar and hard, great for a permeate tube. Water won't stick to the material making it easier to transport and the tube can withstand pressure. They should relate properties of the polymer to why they were used for specific items/purpose. Think why we used that polymer for that layer or part of the filter. |                                                                            |               |                |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |                     |               |  |               |                 |     |  |                |                          |                      |  |             |            |        |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Plastic mesh                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Feed channel spacer            | Polypropylene                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                            |               |                |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |                     |               |  |               |                 |     |  |                |                          |                      |  |             |            |        |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Black plastic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Permeate spacer                | PET                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                            |               |                |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |                     |               |  |               |                 |     |  |                |                          |                      |  |             |            |        |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Cardboard tube                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Permeate collection tube       | PVC or Polypropylene                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                            |               |                |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |                     |               |  |               |                 |     |  |                |                          |                      |  |             |            |        |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Rubber band                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Brine seal                     | Rubber                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                            |               |                |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |              |                     |               |  |               |                 |     |  |                |                          |                      |  |             |            |        |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

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| <p><b>Extension</b></p> <ol style="list-style-type: none"> <li>1. Students can look at conventional tertiary treatment of wastewater to produce recycled water and biosolids. They can have a practical task to build a particle filter and describe how polymers could aid their filtration process. See our Wastewater treatment webpage and our HSC Chemistry page for more information.</li> <li>2. Students can research the effectiveness of reverse osmosis. They can compare water quality data samples from St Marys Water Recycling Plant and St Marys Advanced Recycling Plant. You can also see our Wastewater network page for more information and links to <i>Wastewater treatment plants</i> and <i>EPA pollution monitoring data reports</i> webpages.</li> </ol> <p><b>Q.</b> Why do you think they are monitoring these specific ions in the treated water?<br/> <b>A.</b> To protect the environment and public health. You may also note there is more data for St Marys Water Recycling Plant compared to the advanced plant. Many of these aren't measured as the water would have negligible amounts. Nitrogen and phosphorus are key elements measured as their ions can be used as a nutrient that can cause environmental harm in waterways, such as algal blooms.</p> | <p><b>Sydney Water resources</b><br/> <a href="#">High School</a> see in HSC Chemistry<br/> <i>Make a simple filter</i><br/> <i>Polymers in water and solids recycling factsheet</i></p> <p><a href="#">Wastewater network</a><br/> <i>Wastewater treatment plants</i><br/> <i>EPA pollution monitoring data reports</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <p><b>Conclusion</b><br/> <b>Evaluation questions</b></p> <ul style="list-style-type: none"> <li>• What was the benefit of creating a model? Is it just craft or did it help your understanding?</li> <li>• Can you come up with alternative designs?</li> <li>• Do you think you could improve your design by seeing it in a real-life industrial setting at St Marys Advanced Water Recycling Plant?</li> </ul> <p><b>Reflection activity</b> - students finish these statements</p> <ol style="list-style-type: none"> <li>1. I used to think (at the start of these lessons)</li> <li>2. But now I think (at the end of these lessons)</li> </ol> <p><b>Got students interested in a career with Sydney Water or research and development?</b> See our Sydney Water careers webpage for more information on working here. Find out about the latest research from Sydney Water on our Reports and publications webpage.</p>                                                                                                                                                                                                                                                                                                                                                                   | <p><b>Sydney Water resources</b><br/> <a href="#">Careers</a></p> <p><a href="#">Reports and publications</a></p> <p><b>Find out more</b></p> <ul style="list-style-type: none"> <li>• <a href="http://sydneywater.com.au/education">sydneywater.com.au/education</a></li> <li>• <a href="https://facebook.com/SydneyWater">facebook.com/SydneyWater</a> </li> <li>• <a href="https://instagram.com/sydneywater">instagram.com/sydneywater</a> </li> <li>• <a href="https://twitter.com/SydneyWaterNews">twitter.com/SydneyWaterNews</a> </li> </ul> |