

Ocean Acidification

The other consequence of rising carbon dioxide levels

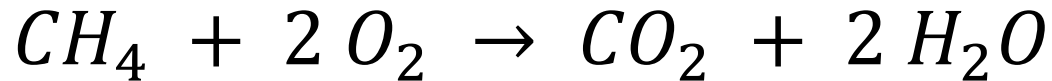
CHEM 1000

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Carbon Dioxide Emissions

- Carbon dioxide (CO₂) is produced whenever anything containing carbon is burned.



- There has been a lot of interest in atmospheric CO₂ levels recently. Why?



Carbon Dioxide in the Oceans

- As the amount of CO₂ in the atmosphere increases, the amount of CO₂ dissolved in the ocean increases. (Henry's Law)
- Atmospheric CO₂ levels have increased by about 35% since the pre-industrial era.
- That means that there is now **35% more carbon dioxide** dissolved in the oceans than in pre-industrial times!



Carbon Dioxide is an Acid!

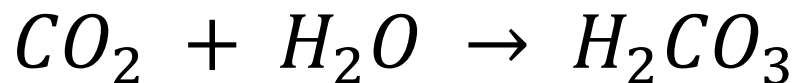
- Carbon dioxide is a nonmetal oxide and a Lewis acid.

- Nonmetal oxides react with water to give acids:

- sulfur trioxide + water → sulfuric acid



- carbon dioxide + water → carbonic acid



How Acidic Should Ocean Water Be?

- Acidity is measured using a scale called pH.
 - neutral water has a pH of 7
 - lower pH = more acidic
 - pH is a logarithmic scale:
 - pH 6 is 10 times more acidic than pH 7
 - pH 5 is 100 times more acidic than pH 7
 - pH 4 is 1000 times more acidic than pH 7



- Tap water pH is usually 5-6 due to dissolved carbon dioxide.
- Ocean water pH is just over 8 due to dissolved salts including calcium carbonate.

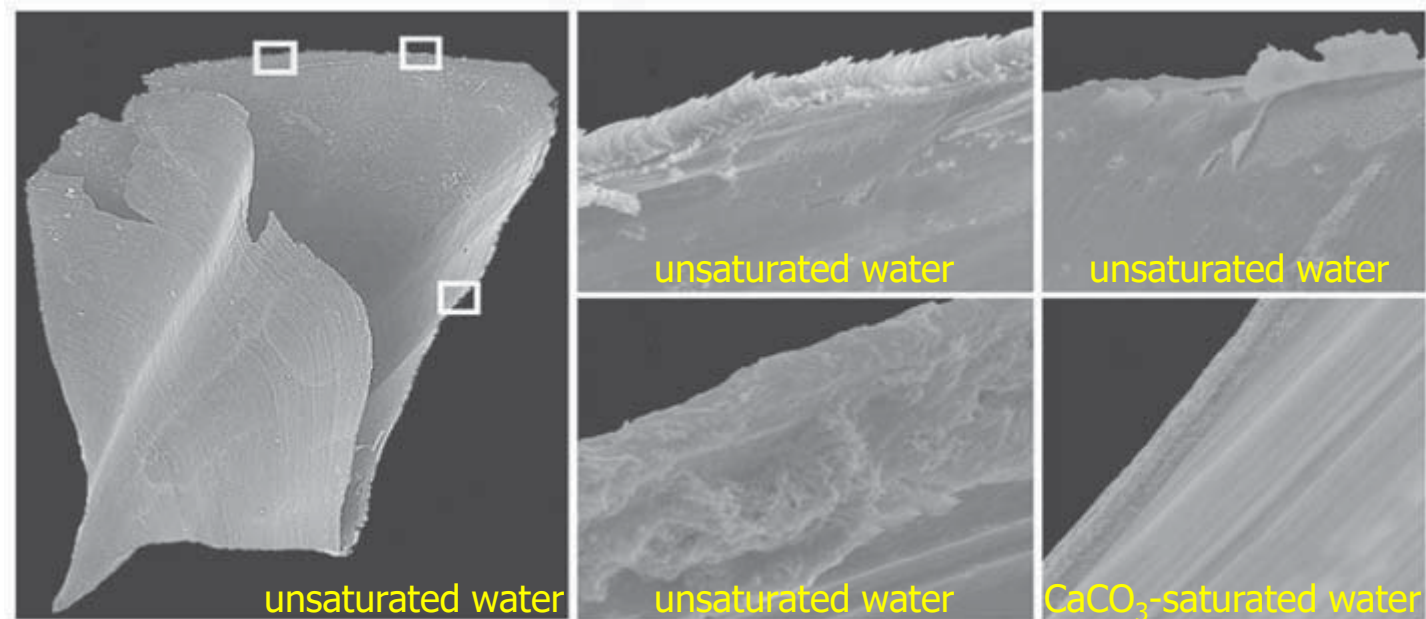


Why Should We Care?

- 250 years ago, the average pH of the ocean was 8.2.
- 25 years ago, the average pH of the ocean was 8.1.
- It's predicted that ocean pH may drop to 7.8 by the year 2100. That would be **two and a half times more acidic** than pH 8.2!
- As ocean pH lowers,
 - The concentration of dissolved calcium carbonate drops dramatically as it reacts with acid in the water.
 - Existing carbonate structures (corals, shells, etc.) could dissolve.
 - It is no longer possible to make new calcium carbonate structures.
- Oceans don't actually have to become acidic ($\text{pH} < 7$) for this to happen. It happens if pH lowers enough that calcium carbonate no longer saturates ocean water.

Consequences of Lower Ocean pH

- The image below shows a pteropod (small shellfish) grown in water not saturated with calcium carbonate (CaCO_3).





In Summary...

- Carbon dioxide in the air dissolves in water. If the amount of carbon dioxide in the atmosphere doubles, the amount dissolved in the oceans doubles too.
- Carbon dioxide reacts with water to make carbonic acid. This makes the water more acidic.
- If ocean water gets acidic enough, it will no longer be saturated with calcium carbonate, and animals with calcium carbonate shells will no longer be able to produce them.
- Some animals affected are at the base of the ocean food web.

J.C. Orr *et al.* Nature (2005) **437**, 681-686; Q. Schiermeier Nature (2011), **471**, 154-156;
The Royal Society policy document (June 2005) ISBN 0 85403 617 2 "Ocean acidification due to increasing atmospheric carbon dioxide"