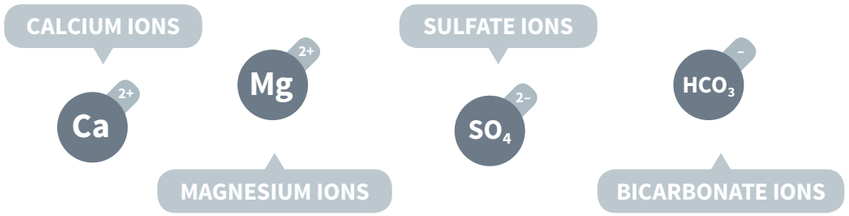
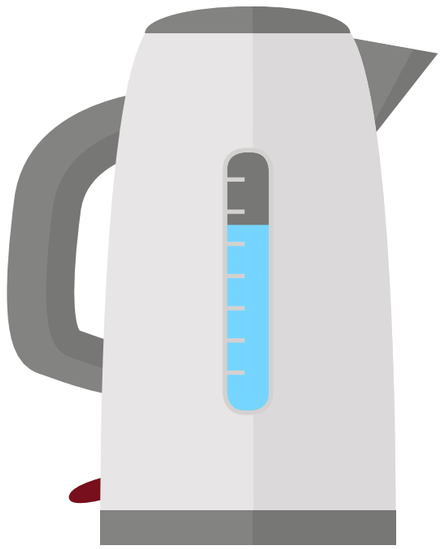
THE CHEMISTRY OF LIMESCALE

Limescale can clog up your kitchen appliances, and build up on your bathroom surfaces. What actually causes this build up? Here's a quick look at the chemistry behind limescale formation, chemicals that can help prevent it, and others that help to remove it.

WATER HARDNESS



'Hard water' is water which contains a large amount of mineral ions, most commonly calcium and magnesium ions. Permanent hard water is mainly due to dissolved calcium and magnesium sulfates. Temporary hard water is mainly due to dissolved calcium bicarbonate. Temporary hardness can be removed by boiling the water, but permanent hardness cannot.



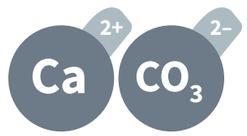
LIMESCALE & SOAP SCUM

$$Ca^{2+}_{(aq)} + 2HCO_3^-{}_{(aq)} \rightleftharpoons CaCO_{3(s)} + CO_{2(aq)} + H_2O_{(l)}$$

Calcium bicarbonate can decompose when heated to form insoluble calcium carbonate – known in this context as limescale – along with water and carbon dioxide. This process removes the temporary hardness from water that the calcium bicarbonate causes.

$$2(C_{18}H_{35}O_2)^-_{(aq)} + Mg^{2+}_{(aq)} \longrightarrow Mg(C_{18}H_{35}O_2)_{2(s)}$$

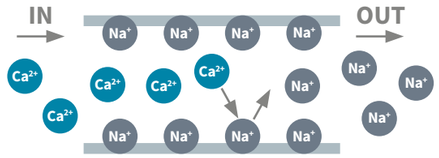
Calcium and magnesium ions in the water can also react with the fatty acids found in soaps to produce insoluble compounds that form a soap scum on bathroom surfaces. The example shown above is that of stearate ions reacting to produce magnesium stearate.

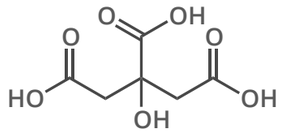


Limescale *consists mainly of calcium carbonate. It can also contain small amounts of the following compounds, depending on water composition:*

calcium sulfate
barium sulfate
magnesium hydroxide
calcium phosphate
zinc phosphate
iron hydroxides

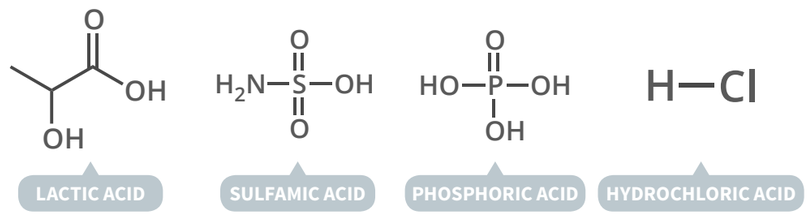
WATER SOFTENERS





Appliances such as dishwashers can soften water by passing it through an ion exchange resin. This exchanges scale-causing metal ions in the water for sodium ions. Compounds such as citric acid and sodium sesquicarbonate can be used to soften laundry water.

REMOVING LIMESCALE



Once limescale has been formed, it can be removed from appliances or surfaces by reacting it with an acid. A variety of acids can be used, all of which react with the calcium carbonate to produce a soluble calcium salt, along with carbon dioxide and water as side products.