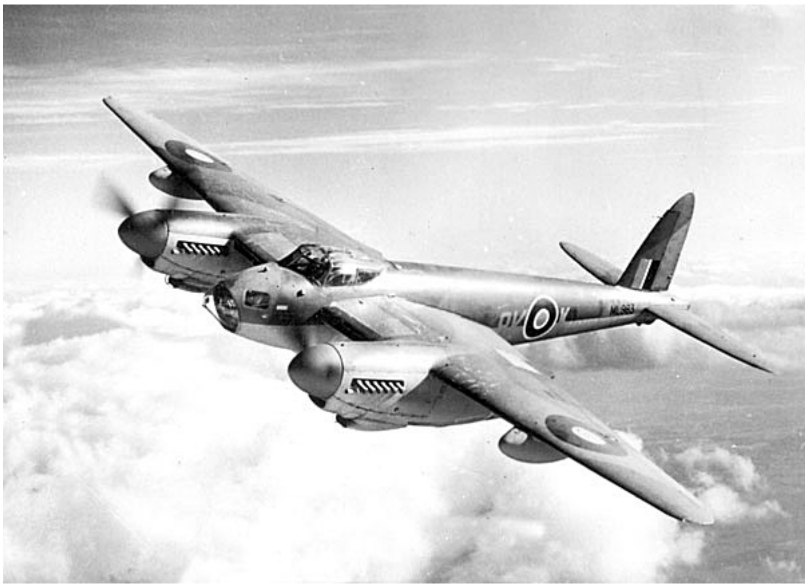
Making aircraft from seaweed!

The De Havilland Mosquito was one of the most successful combat aircraft of the Second World War. Originally designed as a bomber fast enough to outpace enemy fighters, it was also used as a fighter and night fighter. Nearly 8000 were built.



A De Havilland Mosquito

The Mosquito was unusual in that it was built largely of wood. This was for lightness (hence its high speed) but also because metal (mostly aluminium) for aircraft construction was in short supply. The reason for this was that aluminium ores had to be imported from overseas by ships that were liable to be sunk by German submarines. In fact there was an organisation responsible for locating shot-down aircraft, both Allied and German, and salvaging the aluminium to make new aircraft. Aluminium was also collected from homes, so that many British aircraft were made of metal that had once been part of an enemy plane or a British saucepan.

Some of the wood used in the Mosquito was balsa (as used to make model planes) and this did have to be imported - from South America. So the search was on for a substitute material which was as strong and light as balsa. One chemist, Dr Peter Plesch (now a retired professor at Keele University) recalls his work on this project. The idea was to make a foam using sodium alginate, which was readily available form seaweed. Sodium alginate is a long chain polymer and gives seaweed its strength in the same way that cellulose does for wood. Sodium alginate is soluble in water so, to make the foam solid, he reacted it with calcium chloride to make solid calcium alginate:

$$2\ NaAlg(aq) + CaCl_2(aq) \rightarrow Ca(Alg)_2(s) + 2\ NaCl(aq)$$

While sodium alginate is soluble, calcium alginate is almost insoluble. This is because the doubly charged Ca^{2+} ions link alginate chains together. The resulting foam could be set in moulds in the form of planks, 100 cm x 30 cm x 2-3 cm.

However, the planks had to be washed to remove the soluble salts and then dried.

Plesch recalls that

> ‘ The resulting fairly floppy slab of gel, still containing about 9 kg of water per kg of calcium alginate, could be dried in an air oven to a fairly rigid material resembling toast, provided the specimens were no larger than a

> sheet of A4 paper. Anything bigger, let alone an entire slab of gel, warped uncontrollably into bizarre saddle shapes.'

Eventually Plesch devised an entirely new method of drying. Paradoxically this took place under water. The method involved heating the gel electrically. The gel conducted electricity because of the ionic salts that it contained and so the gel could be heated from the inside. He comments that his method of doing it would not have met modern day Health and Safety legislation.

> 'I removed half of the water from the planks of gel by drying them under water. I fixed strips of galvanized iron sheet to serve as electrodes to the ends of the planks, sank them into running water in rubber-lined wooden vats, and connected the electrodes to the 220 volt mains. The heating from the current carried by the salts drove the water and the dissolved salts out through the surface into the cold running water. The process shut itself down when the removal of the salts cut off the current. The planks of foam, then containing only 50% water and free from salts, could be dried in a timber kiln to give hard, undistorted, non-hygroscopic planks of density around 0.1 g cm^{-3}, which was what was needed.

The DeHavilland engineers made up a dummy fuselage and declared the planks of foamed calcium alginate fit for purpose, but by 1944 there was no more need for what would have been an expensive process, because the German U-boat threat had receded. One surviving plank, with its story, is in the Science Museum in London, another one is in Professer Plesch's office at Keele University, as hard as it was when it was made in 1944.