TIDE PODS

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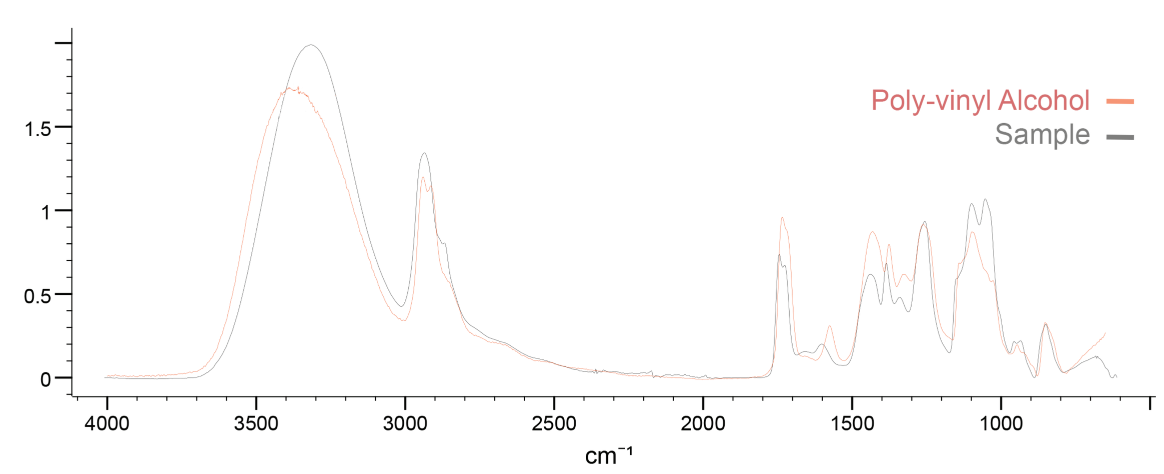
Overview

In 2012, Proctor and Gamble (P&G) released a new kind of laundry detergent: Tide Pods. Tide Pods are laundry pods that come individually portioned and packaged for a single use in the washing machine. Each pod contains three chambers — detergent, stain remover, and color booster — all packaged in a dissolvable film.

We investigated the material properties of the dissolvable film. The casing must be resistant to breakage while being transported, and must quickly dissolve in water. We wanted to explore its strength in transport, its weakness in water, and its life after the washing machine, and see how the chemical structure contribute to these properties.

FTIR Analysis



This infared spectrum analysis shows that the sample of film from the tide pod (black curve) closely matches the spectrum analysis for Polyvinyl Alcohol (red curve), thus confirming that the film on Tide Pods is indeed Polyvinyl Alcohol.

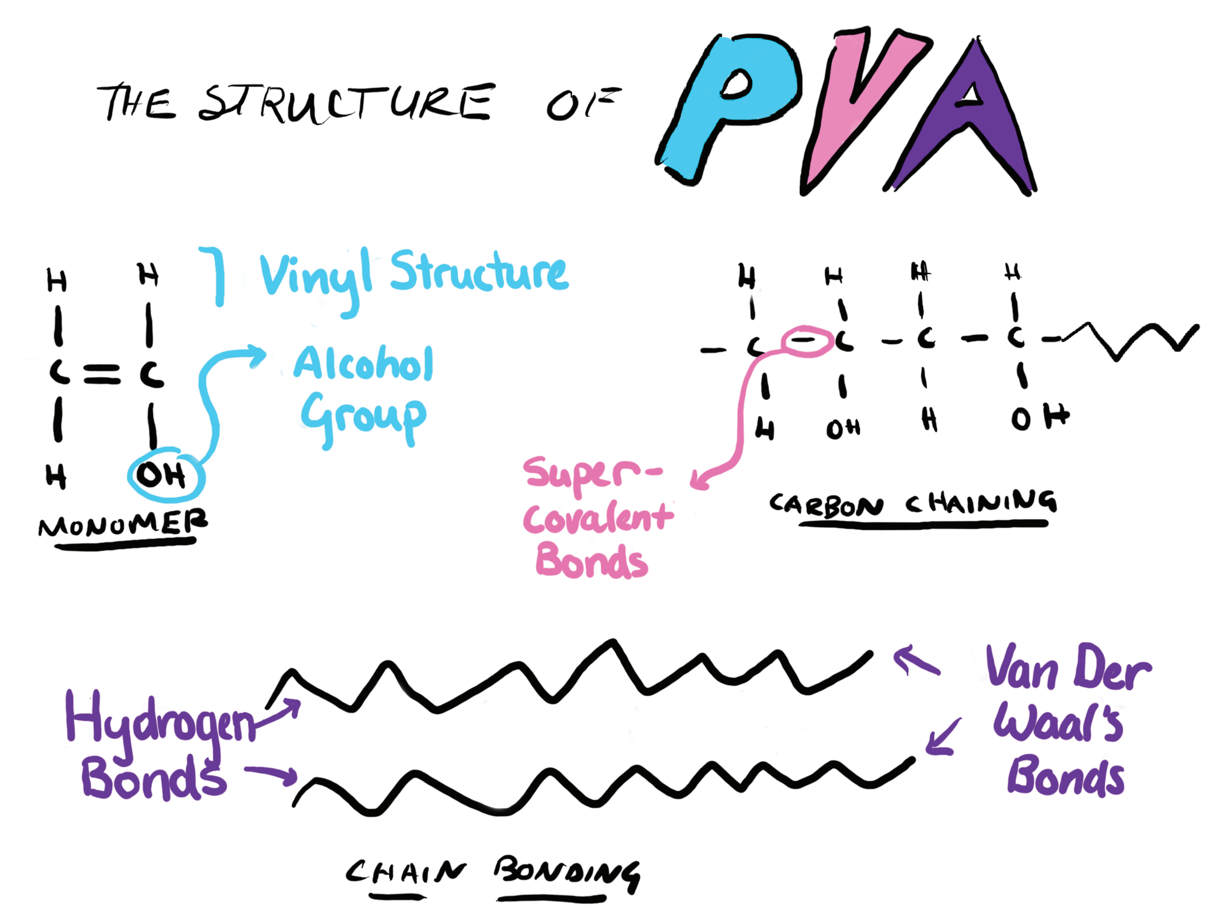
What are Tide Pod casings made of?

We approached the question of what Tide Pods' casings are made of in two different ways: first, researching what P&G has published about Tide Pod films, and second, confirming with our own chemical analysis.

P&G's patent on "packaged product comprising flexible, liquid-filled pouches" states that the three most preferable materials for casings are Polyvinyl Alcohol (PVA), copolymers of PVA, and hydroxypropyl methyl cellulose (HPMC).

To find which of those three materials make up Tide Pod film, we used Fourier-Transform Infrared Spectroscopy analysis (FTIR). FTIR allows us to look at how different materials absorb different wavelengths of light and match test samples to a large database of materials based on the similarities in levels of absorption along this spectrum.

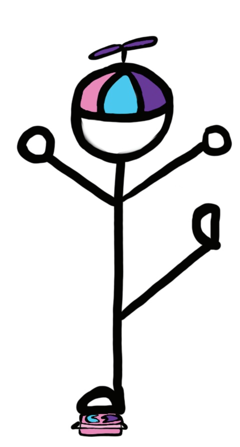
We tested a sample of Tide Pod casing with FTIR and compared it to an existing FTIR result of PVA, which gave us the graph you see to the left. The graph compares the absorption of different wavelengths of light between the Tide Pod sample (in black) and PVA (in red). The strong similarities between the peaks' locations and intensities show that it's very likely that Tide Pods are made of some variant of PVA, confirming P&G's statements.

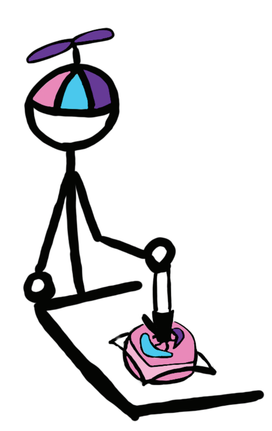


How do Tide Pods survive in transport?

One of the main design considerations for Tide Pods is withstanding forces to prevent popping in transport. We quantified this through impact and compression testing on the Instron. Through our tests, we found that Tide Pods can withstand a surprising amount of force:

196.1 N
of compressive force
(A 7 year old standing on a Tide Pod)



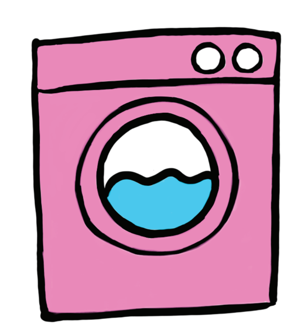


7.5 J
of energy on impact
(A 7 year old stabbing a Tide Pod with a sharpie)

How can a single-chained polymer such as PVA withstand so much force? Our tension tests have suggested that the chains are interlaced with each other. The stress-strain curve has a large section where the strain increases but the stress stays fairly constant. This is an indication of drawing, where the load does not increase; instead, the elongation is due to the polymer chains aligning themselves in the direction of the load.

Crosslinking is another possible explanation of PVA's strength. Crosslinking happens when covalent bonds are formed between chains of polymer, typically through some reactive process. We have observed many characteristics that point to the possibility of crosslinking: the material is strong and elastic (after the tension tests, the film returns roughly to its original size), and there is indication that the chains are twisted together. However, we have not been able to find evidence in literature that indicate that it is possible to have crosslinked PVA that is also water-soluble.

How do Tide Pods dissolve in the wash?

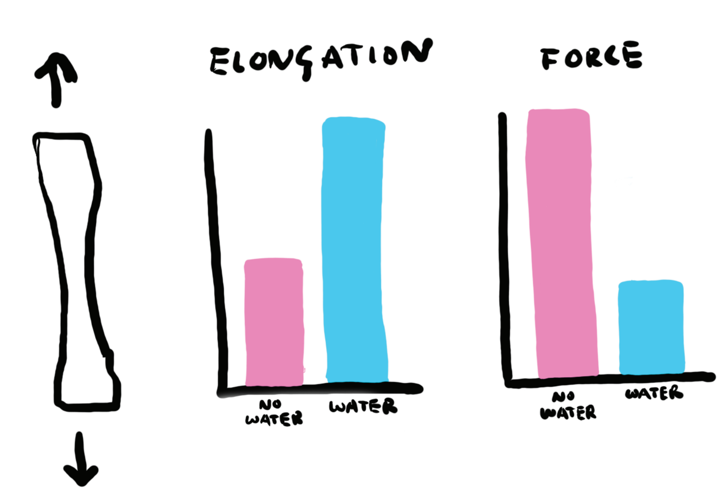


Now that we've established some of the mechanical properties of Tide Pods' casings, let's take a look at what actually happens when you throw them in your washer.

Through multiple tests with Tide Pods placed in a self-stirring beaker, we found that they take 1-3 minutes to dissolve enough to break through the casing and release the detergent; the more objects in the water for it to drag on, or the closer it is to the center of rotation, the faster it will burst.

To further quantify the effects of water on the casing, we tested the amount of tensile stress the film can take before breaking under both wet and dry conditions. Adding 5μL of water increased the amount of elongation by 90%, and decreased the force necessary by 63%.

Dry Sample:
62mm of extension
16.7 N of force



Wet Sample:
118mm of extension
6.1 N of force

Now that we know how much a tiny amount of water affects the force required to pull the Tide Pod apart in the wash, the natural follow up question is: why does PVA dissolve so easily in water? PVA is a simple carbon chain, with every other carbon atom on the chain attached to a Hydroxyl (alcohol) group. The alcohol group has some polarity; since water has the opposite polarity, the alcohol groups form hydrogen bonds with the water instead of the other PVA chains. On a larger scale, this separation of chains causes PVA to dissolve and no longer be a chunk of plastic, but the dissolution does not remove or break down the plastic molecules.

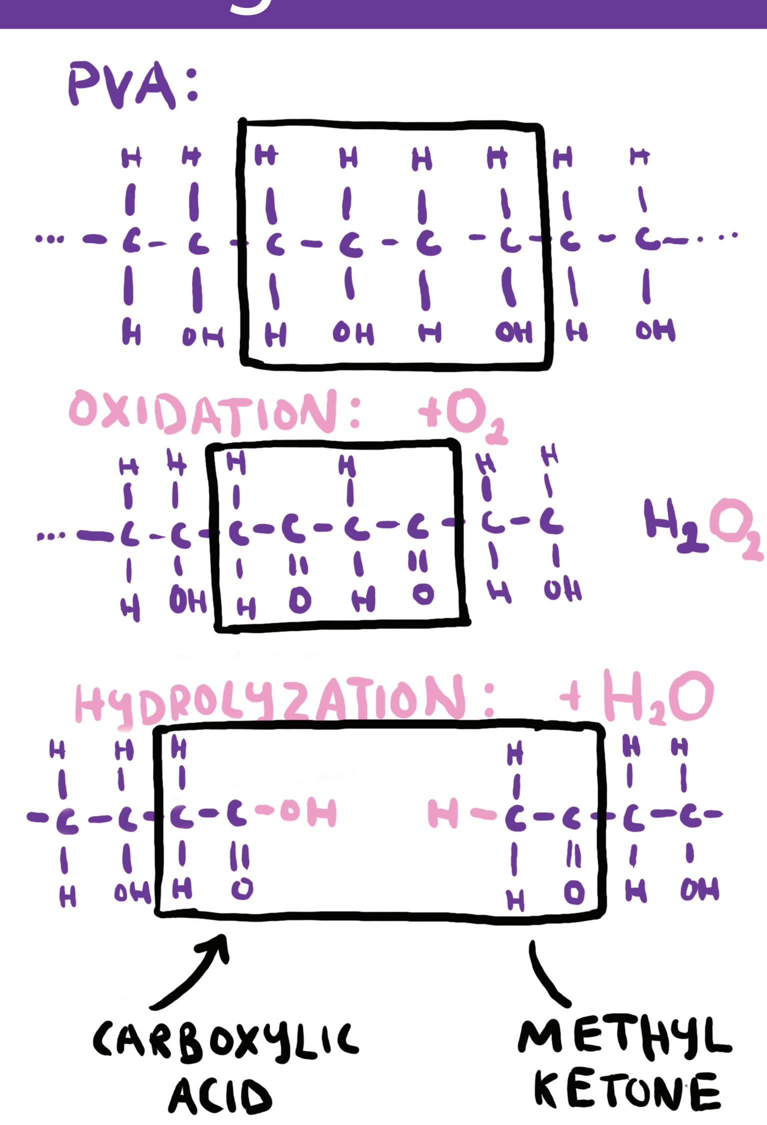
What happens after the washing machine?

PVA's dissolution leaves chains of PVA in the water. Although PVA is nontoxic, it can still cause problems in the environment. The CDC states that PVA may have hazardous effects toward aquatic life. In particular, PVA may be somewhat poisonous to fish, and large amounts of PVA may cause the water to foam, reducing the oxygen content.

Unlike many polymers, PVA is biodegradable. Wastewater treatment plants often bring in microorganisms that can break down pollutants in the water, some of which break down PVA. These microorganisms generally degrade PVA in two steps: oxidation and hydrolyzation. The process of oxidation and hydrolyzation are shown in the figure to the right.

The two products that result from these reactions are methyl ketones and a carboxylic acids. Carboxylic acids are biodegradable, as they are often found in products such as vinegar and milk.The particular methyl ketone that is produced is 2-pentanone, a substance often found in plants, thus also biodegradable.

PVA is one of the few polymers that are biodegradable in this way. For Tide, the consumers, and the world, this is an added benefit to an already useful material.



Conclusion

Is P&G's patent correct? Is PVA the "most preferable" material to construct Tide Pods from?

Between PVA's ability to withstand compression and sudden impact, its dissolvability in water, and its eventual biodegradability, we have shown that PVA meets all the necessary design constraints for Tide Pods, making it an excellent material choice.

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