Lab report – bio-materials

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Material: Cornstarch-Based Bioplastic in the Microwave

Introduction or Purpose: The purpose of this experiment is to transform simple household kitchen materials (cornstarch, water, and vegetable oil) into a solid, biodegradable bioplastic that is completely nontoxic but still retains many of the physical properties often associated with petroleum-based plastics. Traditionally, plastics are polymers consisting of monomers like ethylene, propylene, styrene, phenol, formaldehyde, ethylene glycol, vinyl chloride and acetonitrile. Many of these compounds have harmful effects on environmental and human health in the processes of production and decomposition, but some bioplastics have shown promise as safe alternatives. This cornstarch bioplastic is completely biodegradable, consisting only of Because there is minimal chemical manipulation and there are no additives, this likely does not have the harmful methane emissions that even other corn-based bioplastics like PET have, which release CH_4, an extremely potent greenhouse gas, in the process of decomposition. This means the process of forming PET probably demands highly energy intensive chemical modification. Presumably, cornstarch decomposes easily without significantly releasing harmful byproducts, as if it is a simple plant-based food material. This experiment successfully formed cornstarch-based bioplastic of a solid but rubbery consistency, by combining cornstarch, water, and oil, and heating the mixture until it formed a solid substance. If the proportions of each of these ingredients or the time spent exposed to microwave heating, the flexible or solid state of the material will vary. This project is easily accessible to people of all ages, with very few required ingredients, all of which are readily available in household kitchens.

Ingredients and Amounts:
1 cup corn starch
1 cup water
1 tablespoon oil

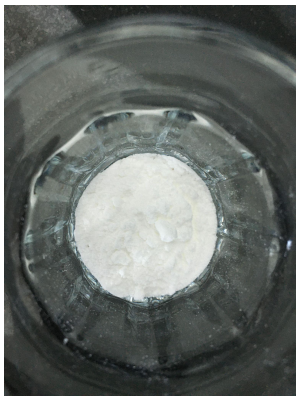
Tools:
Microwave-safe glass container
Microwave oven
Spoon to stir
Cookie cutters

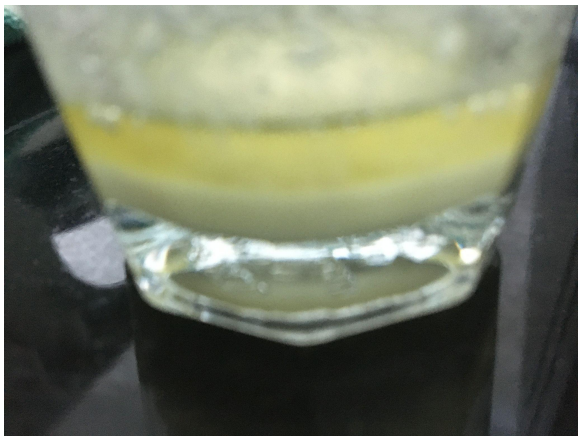
Methods:

1. Measure equivalent volumes of cornstarch and water, measuring and pouring them into a microwave-safe container (1 cup of cornstarch, 1 cup of water) along with 1 tablespoon of oil.
2. Mix thoroughly until there are no lumps remaining.
3. Microwave the mixture on High for one minute (or longer for more rigid plastic)
4. Remove from the microwave and allow to cool completely until it appears solid.
5. Once it has sufficiently congealed and hardened, remove the sheet of bioplastic from the mold and allow to rest.
6. If desired, cut out shapes using a cookie cutter.
7. After it has fully dried, the bioplastic can be manipulated and moved around freely.

Curing time and temperature:
Microwave oven on High heat for 1 minute, oil seemed to boil
15 minutes cooling to room temperature

Results: (photography)

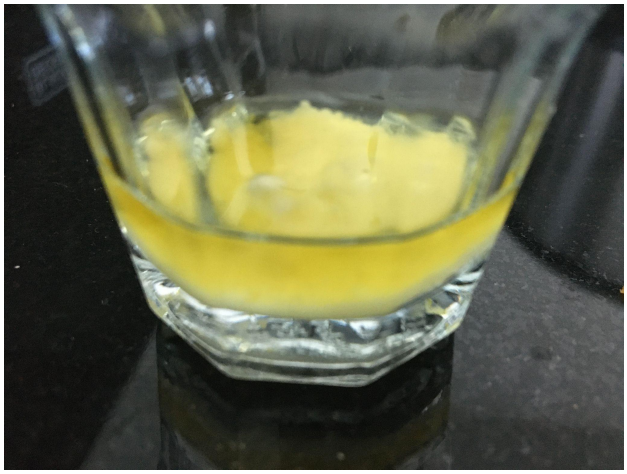

Starch before addition of oil or water

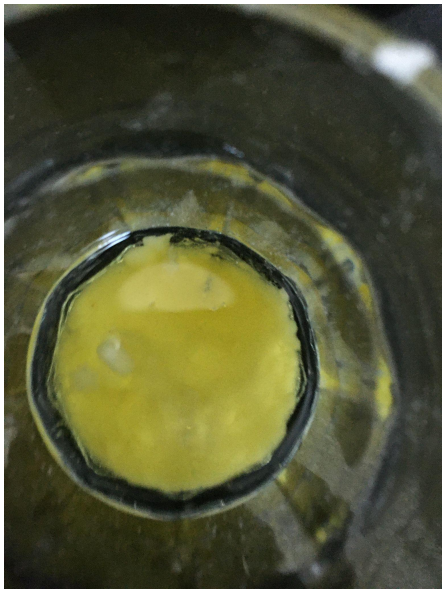

Ingredients as separate layers before heating or mixing thoroughly


Microwave oven


The ingredients bubbled in the process of mixing


Mixture before heating; cornstarch did not dissolve completely and pockets of cornstarch remained


Mixture in the process of cooling


Solid, rubbery texture after heating and cooling

Physical aspect:
Gelatinous and rubbery, somewhat bubbly from cornstarch bubbles that did not fully dissolve

Material observations according to external factors or changes over the time:
Some lumps of starch remained, not fully mixed in with the oil. Oil and water remained somewhat separated (as expected because they are not miscible) until mixed thoroughly because the starch helped emulsify the solution. When oil was first added, it remained in a separate phase on top of the starch, and the starch settled to the bottom again after it mixed. In the microwave, the liquid bubbled and expanded a bit. The ingredients were more miscible when hot, as the solubility of the starch in the oil increased with temperature. The material bubbled as liquid when it first came out of the microwave, then solidified as it cooled. It became rubbery and formed a gel, which progressively dried out to form a more solid plastic-like material.

Conclusions:

The material would have been more rigid if more corn starch was added, and would be more pliable and spongy if more water was added. The oil was added to make the mixture more held together. More time spent in the microwave would make the mixture dry out and become more rigid, eventually becoming brittle and crumbly if left in too long. Further experiments could try different ratios of cornstarch and water, as well as adding different amounts of oil to see if the oil actually has an effect on the texture and success of the material. The instructions proposed using cookie cutters to make shapes out of the bioplastic; this shows that it could be a viable material for things like children's toys. This is a great example of green chemistry combining with science experiments; children's activities often involve nonrenewable toys and craft materials that are ultimately wasted (things like PlayDoh, clay, or other materials) and may contain harmful additives. This represents an activity to teach children about alternatives to petroleum-based plastic, showing that simple cooking ingredients can be healthier and safer for all, and this helps spark a conversation at a young age for children to learn about how plastic is harmful to the environment and to their own health. Rather than simply disparaging the negative aspects, this can be presented as a positive alternative that shows hope and invokes discussion of the value of truly biodegradable harmless materials. This would not qualify as "cradle-to-cradle" if it was simply thrown away after the lab, but if it was upcycled to something usable (like the cookie-cutter dolls depicted in the image in the instructions, included below) it could be truly sustainable. However, the instructions suggested microwaving in a single-use Ziploc plastic bag (LDPE) which is unsustainable and harmful to the environment, so it demeans the intention of this lab. One should use a reusable container instead, and using cornstarch and oil bought in bulk can help this lab become truly zero-waste. This material shows great promise, because once fully dried it can be rinsed under water and washed; perhaps it could be molded into containers or other products used for unreactive material storage because it is food-safe (and probably not tasteful, but as only cornstarch and oil it's even edible!)

Step 4: Molding It