Improving the quality of biopolymers

Popular Science Summary

Today, plastic materials play a very important role in our everyday life. Plastics are used in almost every manufacturing industry nowadays because their physical properties make them very useful in many different areas. They are very versatile and can therefore be manipulated to get a wide range of desirable properties. The major disadvantage with these plastics made by fossil sources is that they are non-degradable and thus, they accumulate in the environment at a rate of 25 million tons per year. Because of this, there is a strong desire for new polymers with degradability to replace the old plastics. A so-called biopolymer.

One group of biopolymers found to incorporate many of the desired properties is the polyhydroxyalkanoates (PHAs). These biopolymers are potential alternatives to plastics made from non-degradable sources. But unfortunately, there is one major disadvantage; they are thermally unstable when heated. The molecular chains break down through chain scission and this results in changed properties of the biopolymer. To be able to use PHA in the industry as a replacement for fossil based plastics, a solution to the thermal instability needs to be found.

Our project was implemented with the aim of improving the thermal stability of two common PHAs; the homopolymer poly(3-hydroxybutyrate) [P(3HB)] and the copolymer poly(3-hydroxybutyrate-*co*-4-hydroxybutyrate) [P(3,4HB)]. This was accomplished by washing the biopolymers with acid solution to remove impurities that contribute to the thermal instability.

After a careful theoretical study had been made, solutions of four acids (acetic acid, formic acid, hydrochloric acid and citric acid) with different properties were chosen as the washing solutions. The biopolymers were washed in an acid solution, and then filtered as Figure 1 shows. Four different analyzing techniques were then used to study the PHAs and the results showed that citric acid was the most successful acid for both biopolymers.

Figure 1. Filtration of the biopolymer dispersion.

Figure 2 below shows the degradation temperature for the as-received P(3,4HB) powder, along with the degradation temperatures measured when the powder had been washed with the four different acids. The results showed a clear increase in the degradation temperature after the powder had been washed. Citric acid gave the most successful result and hydrochloric acid the lowest increase.

The experiment was successful when it came to increasing the degradation temperature by washing the powder with acids. However, the results received concerning the different acids were somewhat unexpected due to the fact that the weakest acid gave the highest degradation temperature, and the strongest acid resulted in the lowest degradation temperature (apart from the unwashed powder). The expected result was that the strongest acid would result in the highest degradation temperature.

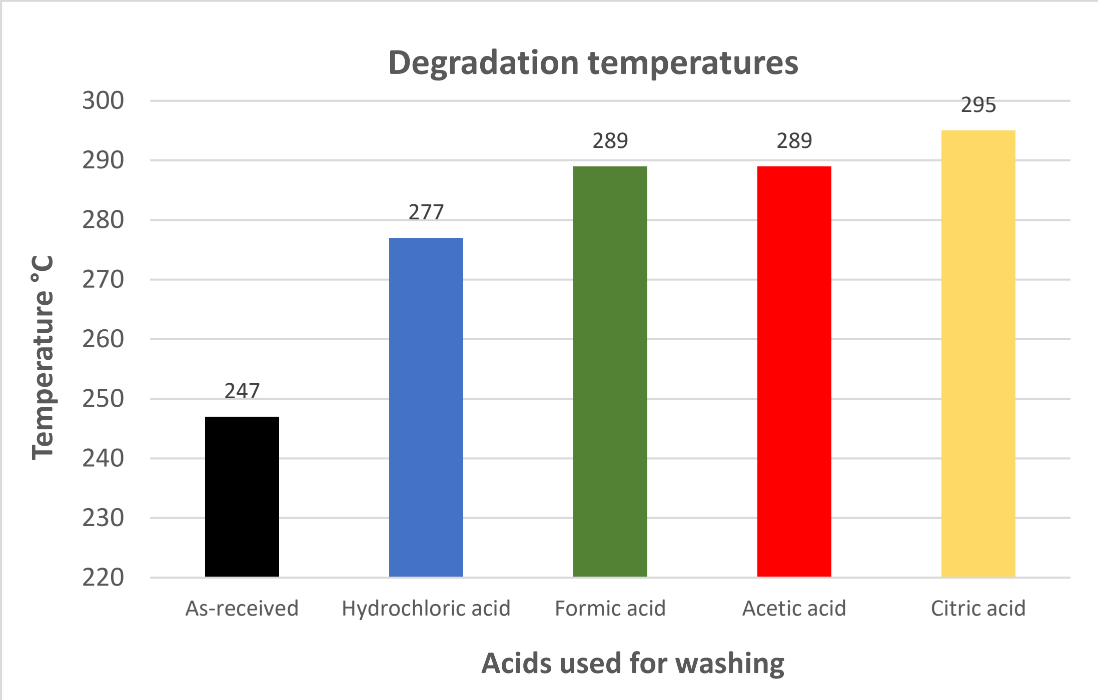

Figure 2. Degradation temperature for as-received P(3,4HB) powder, together with those of powder washed with hydrochloric acid, formic acid, acetic acid and citric acid.

Out of curiosity, the biopolymers were washed with deionized water to see how the degradation temperature would be affected without any acid present. The result was unexpected due to the fact that the degradation temperature was raised for both the biopolymers. For the homopolymer, the result became exactly the same as when washing with citric acid.

Also, it was interesting to investigate how the biopolymers were affected if the acid was mixed into the powder and not washed away before analyzing them. Unfortunately, this had a negative effect on the degradation temperature. These results showed the importance of getting rid of all the acid to improve the thermal stability.

As a conclusion for this project, the degradation temperature was successfully raised when washing the biopolymers with acid. This is good news for the further development of incorporating biopolymers into the industries, and one day hopefully exclusively using them. An interesting point to investigate further is if an increase in the degradation temperature would be possible with only deionized water as washing solution. This would simplify the use of biopolymers, to not mention lowering the costs, for the industries.

The advantage with an increased degradation temperature is that the biopolymer becomes more thermally stable and thereby easier for the industries to incorporate into the process. As a result of expanding the use of biopolymers in industries, the need for plastics made by fossil fuels could be diminished which would have a great positive effect on the environment, and we would create a more sustainable way of living.

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