News Release Detailed Description

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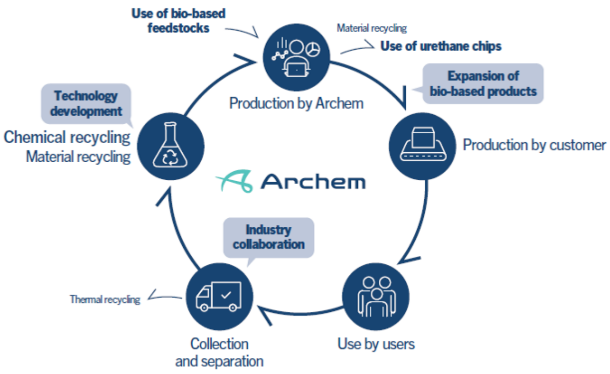
Archem Inc. released a study titled "Hydrolysis of polyurethane foam using carbonated water for chemical recycling" at the 72nd Symposium on Macromolecules (September 26 to 28, 2023) jointly with Nagasaki University. In this release, we introduced a technology that decomposes polyurethane foam by using carbonated water and recycles it into new polyurethane foam, and presented a demonstration sample.

This release is an important initiative for achieving the "establishment of a circular economy," which is a target of our ESG initiatives.



<Concept of a circular economy>

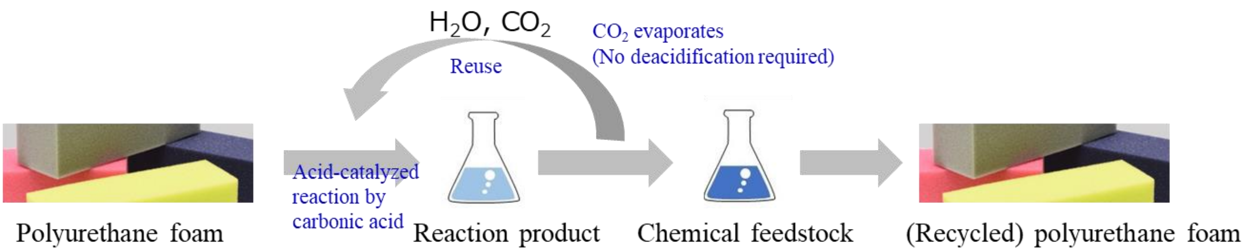
Reference news release

- "Notice of Archem's ESG Initiative Policy"

https://www.archem.co.jp/news/stories/881/

[Background of the research]

To achieve polyurethane foam resource circulation, since 2016 we have been continuing technical exchanges on chemical recycling, which is particularly challenging, with Assistant Professor Suguru Motokucho from the Graduate School of Engineering, Nagasaki University, who discovered an innovative hydrolysis technique using carbonated water[1-9]. Since FY2023, we have shifted to a joint research stage and started collaborative research and development in anticipation of implementing this technique.



<Hydrolysis and recycling of polyurethane foam with carbonated water>

[Outline of the release]

1. Past problems

Calls to establish a circulating society have been rising in recent years, and chemical recycling, which obtains chemical feedstock from waste high-molecular-weight polymers, is drawing attention as a result. In this light, methods for recycling polyurethane, a material applied to a wide range of fields, have seldom been explored until now. Polyurethane foam, which is widely used for seats and mattresses, is a particularly difficult material to recycle because it has a bridged structure and is insoluble. Nor is it applicable to chemical recycling. Also, because it is a foam, polyurethane also has the disadvantages of low density, high transportation cost, and low filling volume into a reactor. As such, polyurethane foam is difficult to recycle because of its characteristics of non-solubility and low density. Furthermore, previously released chemical decomposition methods had the problems that there was a restriction on the filling volume and requirements for addition/removal of catalysts, removal of by-products, and use of excessive amounts of solvent.

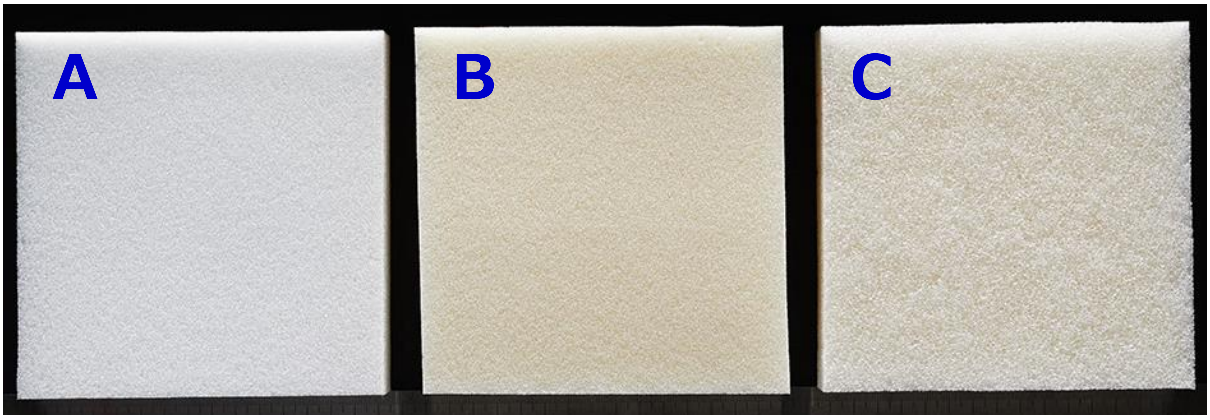
2. Considerations

To solve the problems outlined above, we have been advancing research on a decomposition method using carbonated water. We have also considered introducing a polyurethane foam smashing process during decomposition that uses carbonated water. Furthermore, we have attempted to create (recycle) polyurethane foam by using a collected polyol obtained from that process.

3. Results

Through introducing this smashing process, we successfully increased the charge amount of polyurethane foam, which is to be decomposed by 80 times and the amount of water required for decomposition was reduced to less than 4% (achieving a decomposition efficiency of almost 100%). During the research, we used a temperature range of 160 to 250°C and a pressure range of 5 to 12 MPa as reaction conditions. As described here, it was shown that the process can significantly increase the specimen processing amount in the hydrolysis reactor and reduce the water volume used, resulting in drastic improvement of the processing efficiency. These are marked improvements in the decomposition process.

Owing to the major improvements mentioned above, we obtained a large amount of decomposed material objects and have reached the point where we can start studying the use of those decomposed materials, that is "recycling polyurethane foam from polyurethane foam." The following photographs show polyurethane foam synthesized by using the recycled polyol obtained through this carbonated water decomposition process. A shows polyurethane foam before decomposition, B shows the foam using recycled polyol at 30% (70% is conventional polyol), and C shows the foam using recycled polyol at 100%. As the photographs indicate, although their colors are different, we successfully synthesized polyurethane foam even when recycled polyol is input at 100%. In addition, it was confirmed that the 30% recycled polyol substitution (B) maintained a good cell structure and physical properties that are equivalent to those of the original foam (A).



<Polyurethane foam using recycled polyol A: No substitution, B: 30% substitution, C: 100% substitution>

As described above, it was shown that the recycled polyol obtained through the hydrolysis of polyurethane foam by using carbonated water can be used as a feedstock for polyurethane foam. In addition, because polyurethane foam using this recycled polyol has good physical properties, the feasibility of the concept of a circular economy for urethane foam, which is shown above, was observed.

[Future plan]

With the aim of "maximizing resource recycling through promotion of R&D on chemical recycling," which is a medium- and long-term issue/target of our ESG (environment) initiatives, Archem will continue to conduct research and development on this theme in anticipation of implementing it.

<References>

1) S. Motokucho et al. *J. Polym. Sci., Part A: Polym. Chem.*, **55**, 2004 (2017)
2) S. Motokucho et al. *Polym. Bull.*, **74**, 615 (2017)
3) S. Motokucho et al. *J. Appl. Polym. Sci.*, **135**, 45897 (2018)
4) Element Technology of Green Chemistry for the Resources Recycling of Plastics, editorial supervisor: Takashi Sawaguchi, *CMC Publishing Co., Ltd.* (2019)
5) S. Motokucho et al., *72nd Symposium on Macromolecules,* Sapporo, Hokkaido 3U12 (2022)
6) S. Motokucho et al. *International Symposium on Feedstock Recycling of Polymeric Materials* (Online) (Nov. 29–30, 2021)
7) S. Motokucho et al. *10th Symposium of the Research Group on Green Chemistry, the Society of Polymer Science, Japan, 24th Chemistry Discussion Meeting of Research Association for Feedstock Recycling of Plastics Japan, Joint Workshop*, Kanagawa (Aug. 9–10, 2023)
8) Technologies for Chemical Recycling of Plastic Waste, editorial supervisor: Toshiaki Yoshioka, *CMC Publishing Co., Ltd.* (2021)
9) Development and Applications of Polyurethane, editorial supervisor: Hiroshi Wada, *CMC Publishing Co., Ltd.* (2023)