

Detergency and Biodegradation of Poly(sodium α -hydroxy acrylate) without Surfactant

Sukkyung KIM and Motoko KOMAKI
(Department of Life Science, Ochanomizu University)

1. Introduction

In general, detergents are composed of surfactants as main ingredients and builders as subsidiaries. Surfactants play lots of roles related to interface such as foaming, wetting, penetration, emulsification, solubilization in the detergent solution and builders help the surfactants show their abilities. In the past the most efficient builder in detergent was Pentasodium tripolyphosphate; STPP, but it has been limited in use since about 20 years ago, as a material which occurs environmental problem such as eutrophication in lakes and closed area of water environment. Then Zeolite, trinitrilotriacetic acid sodium salt; NTA, alkali salts and polyelectrolytes for substitutes have been studied and some of them have been used.¹⁾ Among them, polyelectrolytes are still being studied actively for functional effectiveness and environmental acceptability.

Poly(sodium α -hydroxy acrylate); PHA as a polyelectrolyte has been studied in our laboratory since 1994 and it has been reported that PHA shows excellent chelating effect and buffer action and increases the detergency for artificially soiled cloths with surfactant, α -olefin sulfonate; AOS.²⁾

In this report, detergency performance and biodegradation of carboxylate polymers are reviewed, with special attention to PHA and compared with those of poly(sodium acrylate); PA and polyvinyl alcohol; PVA. In addition the content of the present experiment and the future work are introduced.

2. Enhancement of Detergency and Biodegradation of PHA, PA and PVA.

Polyelectrolytes were reported that they have optimum molecular weight for detergency.³⁾ The molecular weight for the most efficient detergency is about 8,000 and 10500 for PA and PHA, respectively.^{3,4)}

Generally the higher the molecular weight the polyelectrolytes have, the poorer the biodegradation, and the lower the molecular weight they have, the better the biodegradation.⁵⁾

Table 1. Representative Polymeric Carboxylate Structures⁹⁾

| Raw materials | (X=CO ₂ NA) | Polymers |
|------------------------------------|----------------------------|--|
| 1. Acrylic acid | Polymerize \rightarrow | $\text{[-CH}_2\text{-CH-]}_n$ X |
| 2. Maleic anhydride | Polymerize \rightarrow | [-CH-CH-]_n X X |
| 3. Acrylic acid + Maleic anhydride | Copolymerize \rightarrow | $\text{[-CH}_2\text{-CH-]}_m\text{[-CH-CH-]}_n$ X X X |
| 4. Starch | Oxidize \rightarrow | $\text{[-CH-CH-O-CH-O-]}_n$ X X CH ₂ OH |
| 5. Alginate acid | Oxidize \rightarrow | $\text{[-CH-CH-O-CH-O-]}_n$ X X X |
| 6. Epoxysuccinate | \rightarrow | [-CH-CH-O-]_n X X |

Performance is best for large N. Biodegradation is best for small N.

Detergency and biodegradation of carboxylate polymer such as PA and PHA have long been studied. Abe and Matsumura found it by measuring the physico-chemical properties of the aqueous solution of 38 carboxylate builders that detergency of the formulations containing the carboxylate builders correlate well with their dispersing capacities for manganese dioxide and chelate stability constants with calcium ions.⁷⁾ Matsumura studied about the builder performance and biodegradation of copolymer, PA containing Vinyl Alcohol groups and found that the detergency is dependent on the content of carboxylate groups in the polymer and the biodegradation is dependent on the content of Vinyl Alcohol moieties in the polymer chain.⁵⁾ And also he studied the builder performance and the biodegradation of partially dicarboxylated Amylopectin; DCA_p and found that it shows better performance with increase of the molecular weight but rather poor

biodegradation.⁸⁾

On the other hand, it has been recognized that PVA is effective for anti-redeposition of oily soil onto various fabrics than STPP⁹⁾ and that anionic PVA has marked effect for anti-redeposition of α -Fe₂O₃ onto cotton and polyester.¹⁰⁾ Matsumura and co-workers reported the excellent biodegradation of PVA¹¹⁾¹²⁾ and Winursito found that dicarboxylated starch with high dicarboxylation degree is resistant to biodegradation but showed good builder performance in detergent formulation.¹³⁾ Suzuki and co-workers also reported complete decomposition of PVA by a bacterium, *Pseudomonas* 0-3.¹⁴⁾

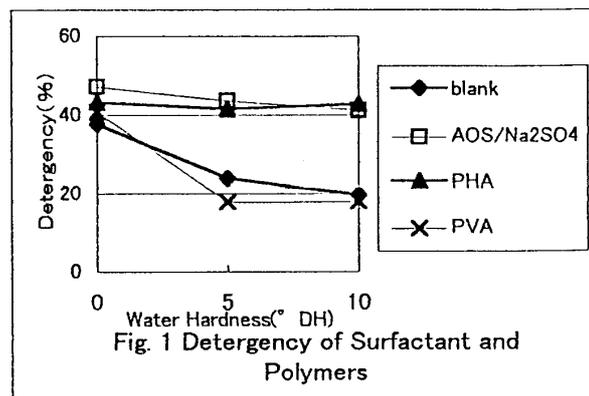
For PHA of the molecular weight 10500, 0.2% solution without surfactant showed the maximum and even better detergency than surfactant (AOS 0.04%, salt 0.16%) and better biodegradation than PA with the molecular weight of 30000.⁴⁾

3. Detergency performance of PHA

In order to make sure that PHA solution without surfactant has excellent detergency performance and to compare the detergency with another polymer similar to PHA in chemical structure, the detergency test was first conducted with 0.2% solutions; AOS/Na₂SO₄, PHA, and PVA.

The detergency was determined by the Tergo-O-Tometer with improved artificially soiled cotton test pieces in the hard water conditioned to 0°DH, 5°DH, and 10°DH. The fabric to liquor ratio was 1:50 and the temperature 30°C. Light reflectance of the test swatches before and after the washing test was measured by means of Handy Colorimeter; Model NR-3000, Nippon Denshoku Ind. Co., Ltd. and the value of K/S ratio was calculated from Kubelka-Munk equation to obtain the detergency.

As shown in Fig. 1, PHA solution without surfactant had detergency nearly as good as AOS solution containing salt. It means that PHA in solution simultaneously plays two roles of surfactant and salt. Furthermore the detergency



of PHA was much higher than that of PVA and barely influenced by water hardness.

In conclusion, PHA can be evaluated to have good detergency performance without surfactant. But it is unknown to which ingredients of the soil on the fabric PHA is effective or that PHA has anti-redeposition effect of some soil. For these questions it will be investigated further and biodegradation test will be conducted as well.

4. Reference

- 1) Y. Abe, Hyoumen., 19, 542(1981)
- 2) M. Satou, Sotsuronbun, (1994)
- 3) Y. Abe, S. Matsumura and K. Sakai, Yukagaku., 30, 31(1981)
- 4) A. Yamamoto, Sotsuronbun., (1997)
- 5) S. Matamura, H. shigino and T. Tanaka, J. Am. Chem. Soc., 70, 659(1993)
- 6) M. M. Crutchfield, Ibid, 55, 58(1978)
- 7) Y. Abe, Yukagaku., 26, 416(1977)
- 8) S. Matsumura, K. Aoki and K. Toshima, Ibid, 71, 749(1994)
- 9) M. Kimura, M. Komaki, and T. Nakajima, Senishouhishi, 33, 603(1992)
- 10) N. Obata, and K. Nobuaki, Nihonkascigakkaishi, 42, 1065(1991)
- 11) S. Matsumura, J. Takahashi and S. Yoshikawa, Koubunsironbunshu, 45, 317(1988)
- 12) S. Matsumura, J. Takahashi, S. Macda and S. Yoshikawa, Ibid, 45, 325(1988)
- 13) T. Suzuki, Y. Ichihara, M. Yamada and K. Tonomura, Agr. Biol. Chem., 37, 74(1973)
- 14) I. Winursito and S. Matsumura, J. Jpn. Oil Chem. Soc., 45, 723(1996)