

ADDITION REACTION OF METALLIC SALT OF GLYCINE WITH ETHYLENEOXIDE AND ITS ISOELECTRIC ZONE

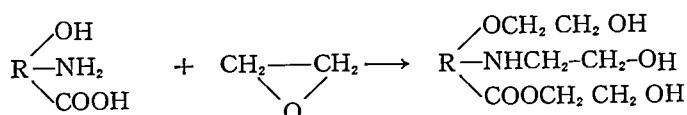
Tadashi ISHIKAWA and Hisao HIDAKA

This paper deals with the addition reaction of metallic salt of glycine with ethyleneoxide on one of the basic investigations of amphoteric surfactant.

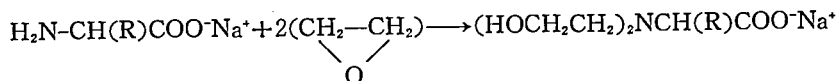
Ethyleneoxide adduct of glycinate was N-2-hydroxyethyl type $\begin{matrix} \text{H}(\text{OCH}_2\text{CH}_2) \\ \text{H}(\text{OCH}_2\text{CH}_2) \end{matrix} \begin{matrix} \text{CH}_2 \\ \text{CH}_2 \end{matrix} \text{)}_p \text{NCH}_2 \text{COOM}$ and the mole number of ethyleneoxide was decided with the methylene shift of NMR and paperchromatography. From the measurement of electric conductivity in the aqueous solution for the dependence to pH, pure-glycine have pI 6.00 of isoelectric point in a narrow pH range, while the conductivity of ethyleneoxide adducts in the case of sodium, potassium and lithium salt comparing with calcium and magnesium salt was found to have wide-spread minimum value in the range from pH 3 to pH 12.

As the result, it was preferable to express the terms isoelectric zone than naming the isoelectric point.

Ethylene Oxide (EO) is generally very reactive to groups with activated hydrogen. It is well known that EO can easily add to every group on the case of the compound having hydroxy, amino and carboxylic group³⁾.



There are few studies on the addition reaction of amino acid with various alkylene oxides^{4, 5)}.



The series of glycine-ethyleneoxide adducts were reported to be used as the removal reagent of sulfur compounds from air and town gas⁶⁾ and many other usages are thought.

To add EO to only amino group of glycine selectively metallic salt of carboxylic groups was formed and competitive reaction was carried out in the aqueous solution.

Various adduct compounds to the introduced EO mol number were identified with NMR and paper chromatography.

Electro conductivity was measured with Kohlaush bridge.

Experimental

Materials. Ethylene Oxide (EO) ; Used a commercial origine by Nissoyuka Industries Co, Ltd. Glycine ; Made by Daiichi Pure Chemicals Co, Ltd. and recrystallized.

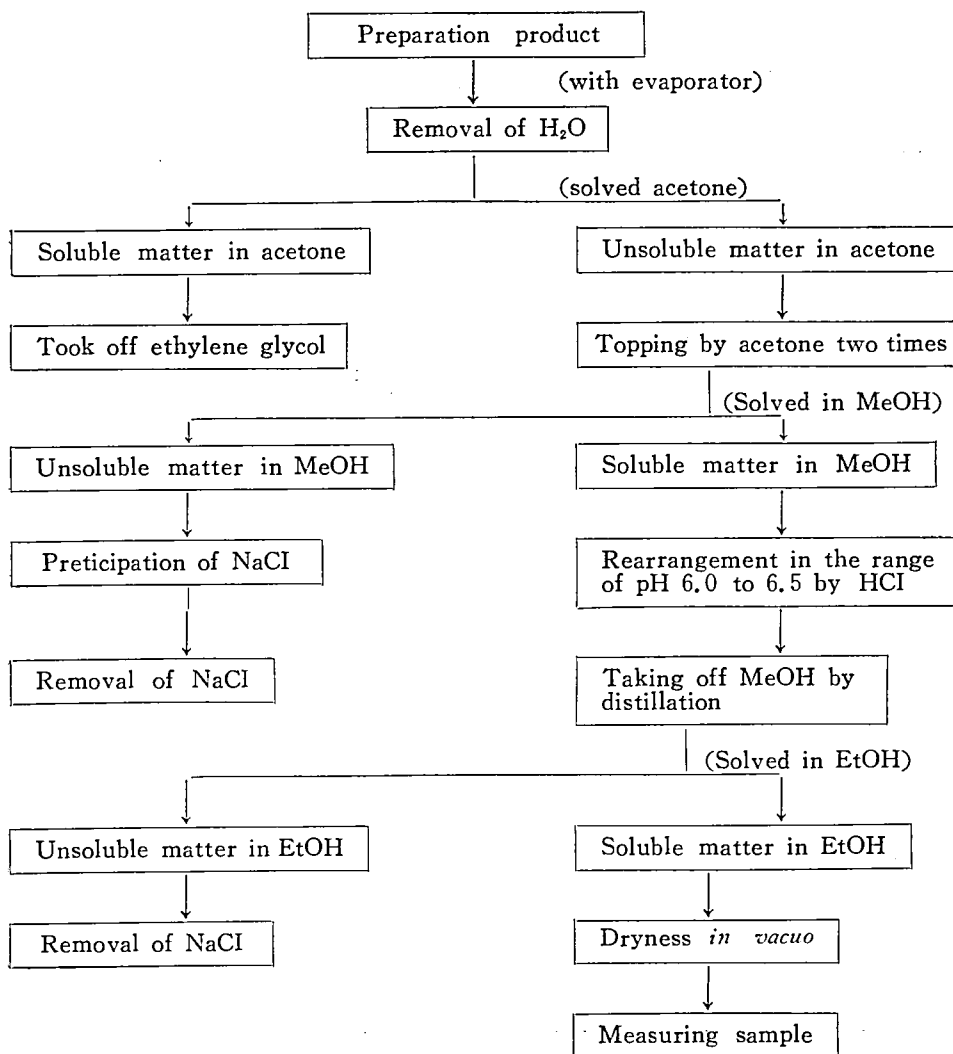
Hydroxide, NaOH, KOH, LiOH, Ca (OH)₂ and Mg (OH)₂ was of commercial origin without purification.

NMR Spectra. MH100 Spectrometer made by Japan Electric Optical Laboratory was used in D₂O as solvent on the base of DSS as a reference.

Paper Chromatography. The adducts was developed for 24 hours with 97% ethanol-H₂O (63; 37) w/w in usual one dimentional method^{7 8)} with Tokyo Filter Paper No. 51 using ninhydrine as detector. Rf value of products was found.

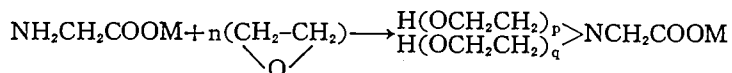
The mesurement of electric Conductivity. Kohlrausch-Bridge Type K-1A Yokogawa Electric works, Co, Ltd. Tokyo Japan, was employed. Electrode for liquid was type 2762 Yokogawa Electric Works Co, Ltd. Its electrode coefficient is $K=0.0667\text{cm}$ at 25°C. Electrodeplates were coated with platinum black to diminish polalization. 2.0g of this sample was solved in 100ml of aqueous solution. This solution was divided in two parts. One part added NaOH solution and gradually changed pH in the same interval. The specific electric conductivity was measured with Kohausch bridge at 30°C in the thermostat.

Experimental Procedure, 30g of Glycine (0.4 mol) was dissolved in 20% aqueous solution of 16g of NaOH or each alkali metallic hydroxide (0.4 mol). The above solution was placed in the 500ml three necked round bottle flask equipped with a stirrer, a reflux condenser connected with dropping funnel and a thermometer. 35.2g of EO (0.8 mol—2 fold mol equivalent), or 105.6g of EO (2.4mol—6 fold mol equivalent) was dropped in ice cooling bath on stirring. And then stirring-heated at 80~90°C for 4 hours. The water in the reaction mixture was took off with evaporater to gain high viscous jelly liquid. Added acetone and heated topping. The soluble in acetone was etylene glycol which EO reacted with H₂O. The above acetone soluble solution was repeated two times. Included acetone was took off by distillation. The insoluble part was solved in hydrochloric acid-methanol solution. And at that time the crystal of sodium chloride was precipitated and isolated with filtration. Methanol was taken off by distillation, solved in ethanol, filterated sodium chloride similarly. The white viscous liquid was gained, dried *in vacuo* and was used as measuring sample. It was very hygroscopic in air.

Isolation of reaction product

Results and Discussion

Reaction formula is written as follows.



Here M means employing NaOH, KOH, LiOH Ca(OH)₂ and Mg(OH)₂.

Alkali hydroxide is a role of the catalyst of EO addition amino group as well as of protection not to add EO to carboxylic group.

Paper chromatography serves mainly for isolation of different kinds of EO adducts. R_f value of adducts of sodium salt, in which 2 fold mol EO and 6 fold mol EO was introduced respectively was found as illustrated in Fig. 1.

2 EO introduced products had two spots of 1:1 adducts that is N-2-hydroxyethyl glycinate (R_f=0.78) and unchanged glycine (R_f=0.61), while 6 EO introduce dreactant had the only spot of 1:3 adduct (R_f=0.90).

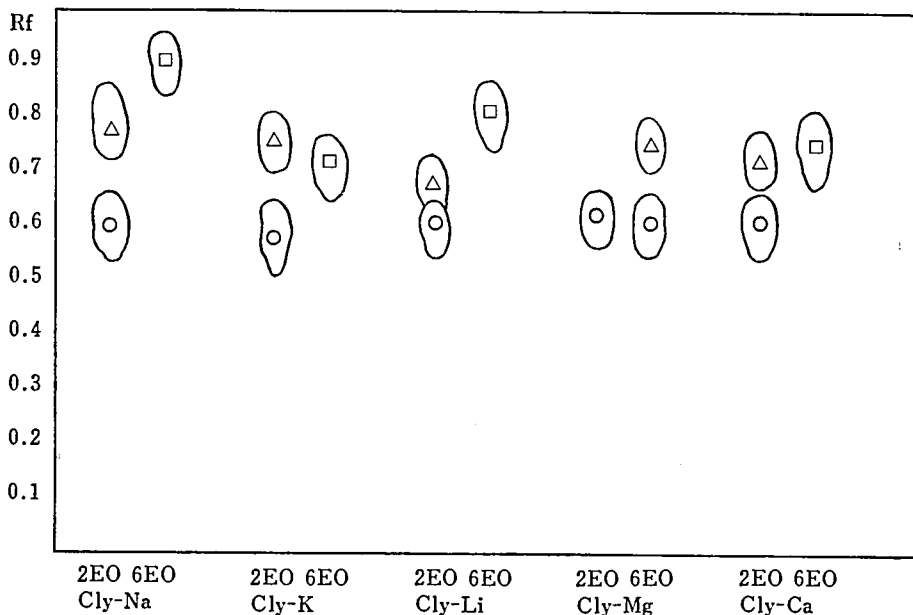


Fig. 1 R_f value of metallic salts EO adducts

2EO or 6EO; mean reaction introducing mol EO number.

O ; unchanged glycine (R_f=0.61)

Δ ; 1:1 adduct

□ ; 1:3 adduct

Developing solvent ; EtOH-H₂O=63:37 w/w% Detector ; ninhydrine

R_f value of unchanged glycine was almost constant from 0.58 to 0.62 to all alkali salts. On the other hand, R_f of 1:1 adduct, which 2 fold equivalent EO was introduced to be made had various value. This reason was presumed to be the difference of travelling of metallic salt in the developing solvent.

On the adducts introduced by 6 fold equivalent EO, there was absence of unchanged glycine and 1:3 adduct of sodium N-[2(2'-hydroxyethyl)ethoxy] N-

2-hydroxyethyl glycinate was only presented as illustrated in Fig. 1.

One mol EO was easily added with amino group to form 1:1 adduct. And next immediately reaction was estimated to proceed to 1:3 adduct via 1:2 adduct. Though the existence of 1:2 adduct was not confirmed, 1:2 adduct was thought to be made little.

Even if EO mol number was increased to 10 fold mol number, the more than 1:4 adduct was not prepared in the reaction condition of this experiment.

As shown in NMR chart in Fig. 2-1, methylene shift of glycine was 3.18 ppm of the singlet peak, methylene shift of N-group side in the N-2-hydroxyethyl was 2.71ppm of triplet peak ($J=0.58\text{cps}$) and the other shift in the hydroxy group side 3.64ppm of triplet ($J=0.58\text{cps}$). About 4.7ppm of overscaled wide peak was of DOH.

The ratio of integral of each methylene group was found to be 1:1:1. From this result, the EO 2 mol introduced product was identified to be 1:1 adduct of N-2-hydroxyethyl glycinate.

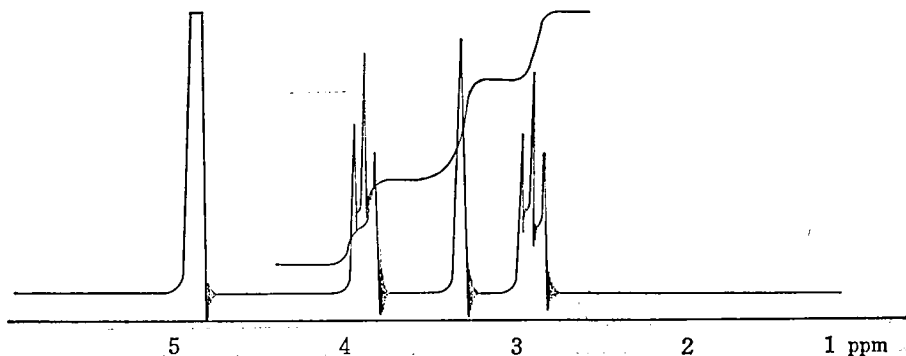


Fig. 2-1 NMR Spectra of Gly-Na 2 fold mol EO.
 $\text{DOCH}_2\text{CH}_2\text{NHCH}_2\text{COONa}$

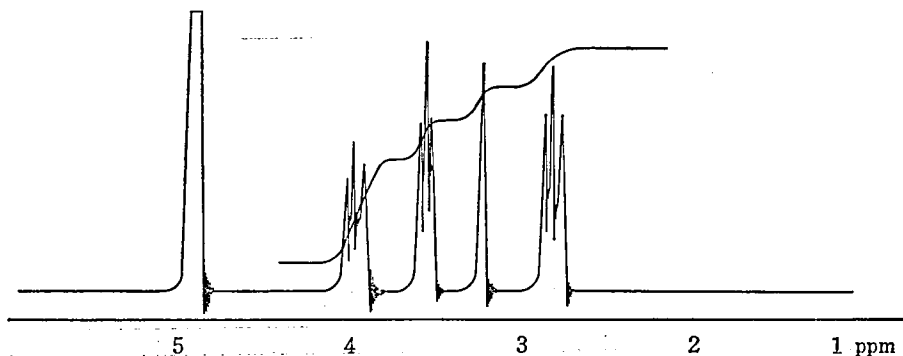
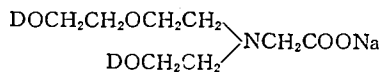


Fig. 2-2 NMR Spectra of Gly-Na 6 fold mol EO.



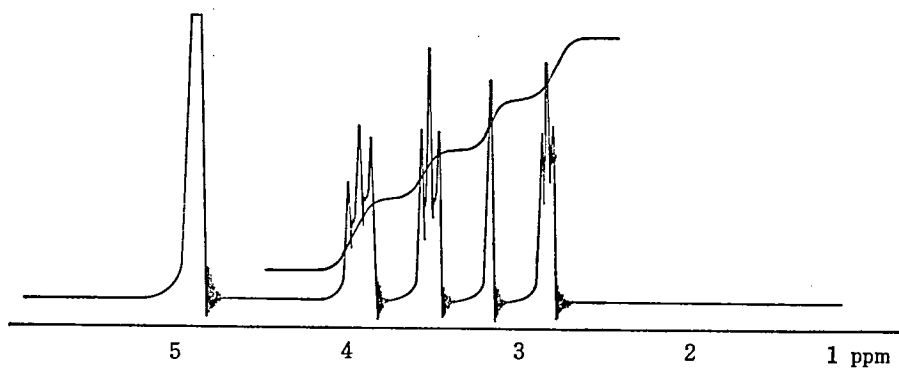


Fig. 2-3 NMR Spectra of Gly-Na 10 fold mol EO.

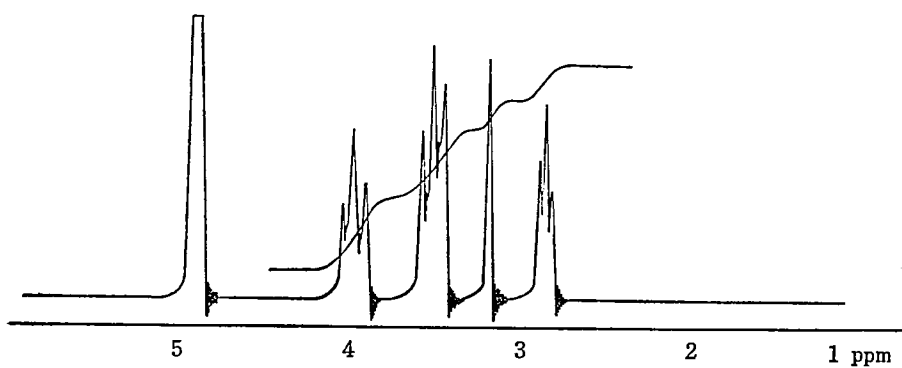
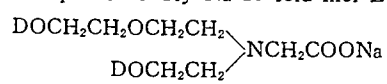


Fig. 2-4 NMR Spectra of Gly-Ca 6 fold mol EO.

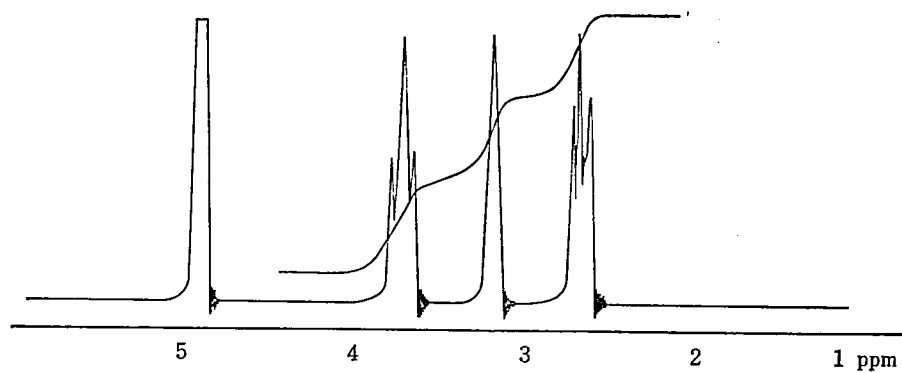


Fig 2-5 NMR Spectra of Gly-Mg 6 fold mol EO.

NMR spectra of the EO 6 mol equivalent introduced reaction product was shown in Fig. 2-2. 3.23ppm of singlet peak was the methylene shift of glycine and had two proton integral. Three triplet peaks having the same integral were 2.76ppm ($J=0.52\text{cps}$) of two methylene groups neighboring amino acid, 3.67 ppm ($J=0.52\text{cps}$) of two methylene groups neighboring two hydroxy groups and 2.94ppm of two methylene groups on both sides of ether linkage. Spectra of the EO 10 fold mol equivalent was very similar to the EO 6 fold mol as shown in Fig. 2-3.

The EO 6 fold mol equivalent reaction product of calcium salt was 1:3 adduct as given in Fig. 2-4. A reaction product of magnesium salt was 1:2 adduct as given in Fig. 2-5.

As illustrated in Fig. 3-1, glycine shows V type curve. Its isoelectric point was $pI=6.00$ and agreed with the value of literature cited. It was considerably recognized that EO adduct of alkali salt of sodium, potassium and lithium had a wide-spread minimum value like U type in the range from pH 3 to pH 12.

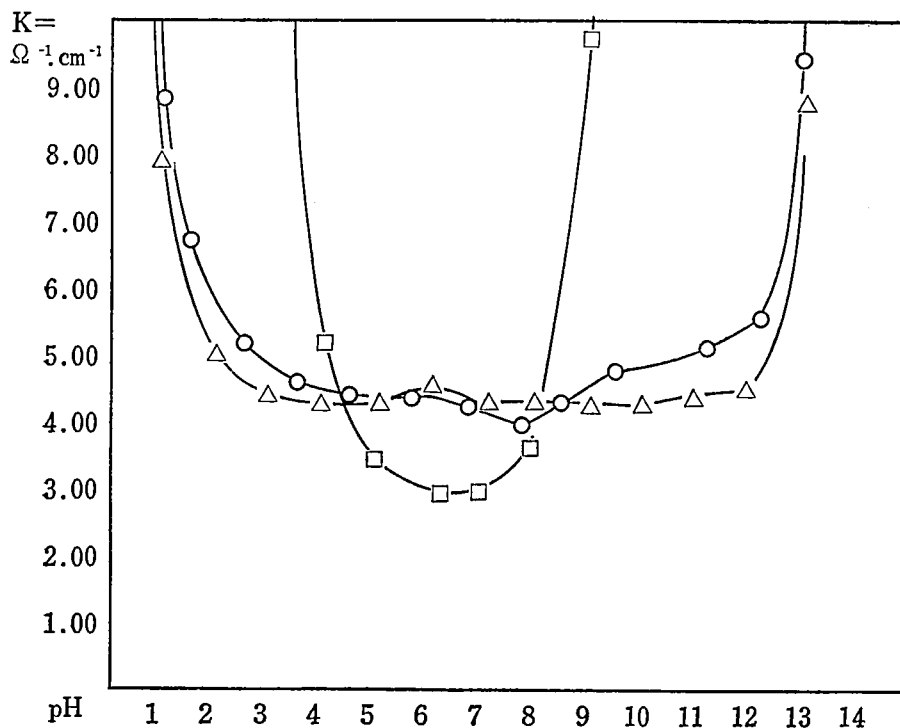


Fig. 3-1 Specific conductivity to pH of sodium glycinate adduct.

- — Pure Glycine
- — Sodium Glycinate+2EO
- △ — Sodium Glycinate+6EO

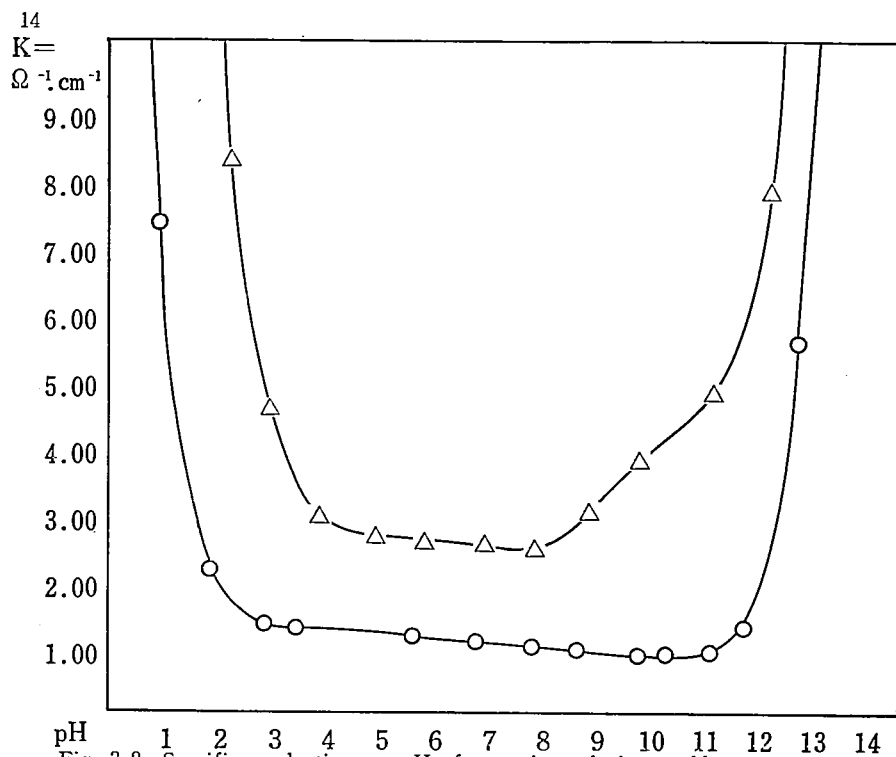


Fig. 3-2 Specific conductivity to pH of potassium glycinate adduct.

○ — Potassium Glycinate+2EO △ — Potassium Glycinate+6EO

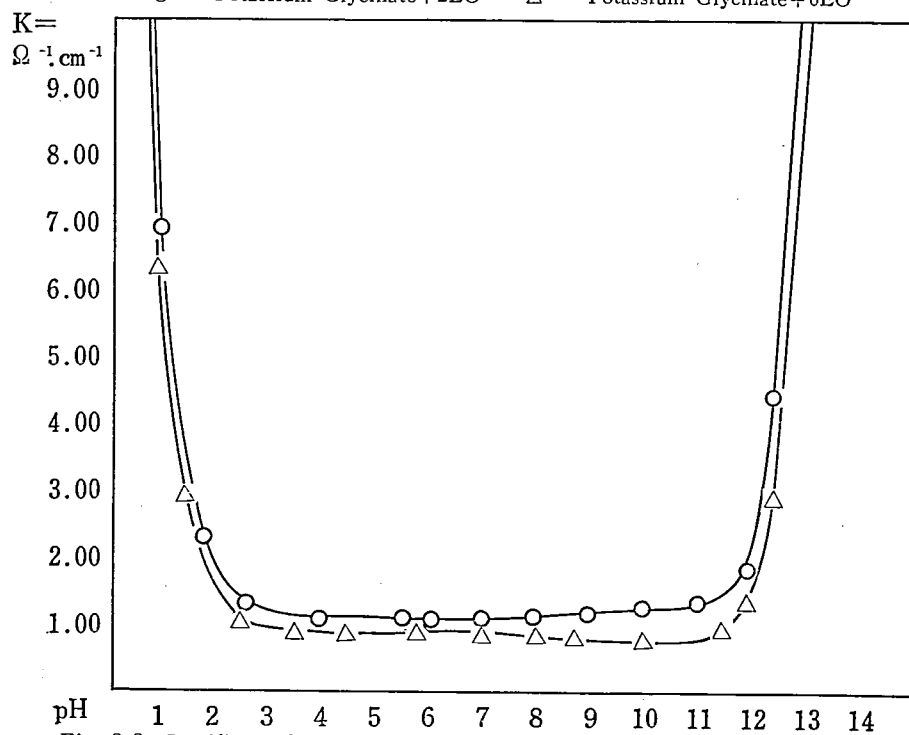


Fig. 3-3 Specific conductivity to pH of Lithium glycinate adduct.

○ — Lithium Glycinate+2EO △ — lithium Glycinate+6EO

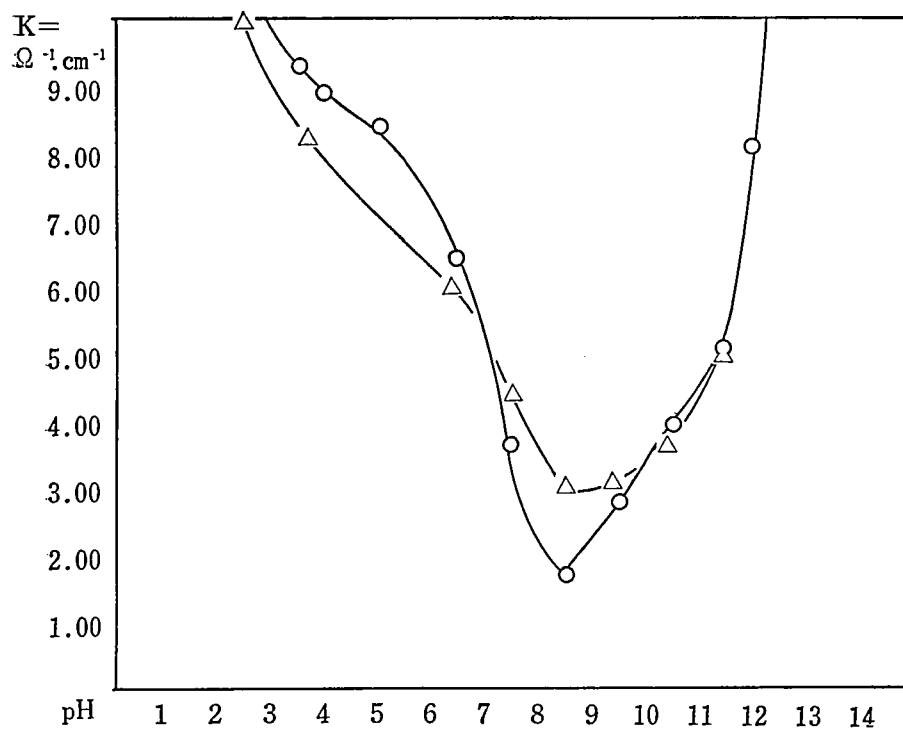


Fig. 3-4 Specific conductivity to pH of calcium glycinate adduct.

○ — Calcium Glycinate+2EO △ — Calcium Glycinate+6EO

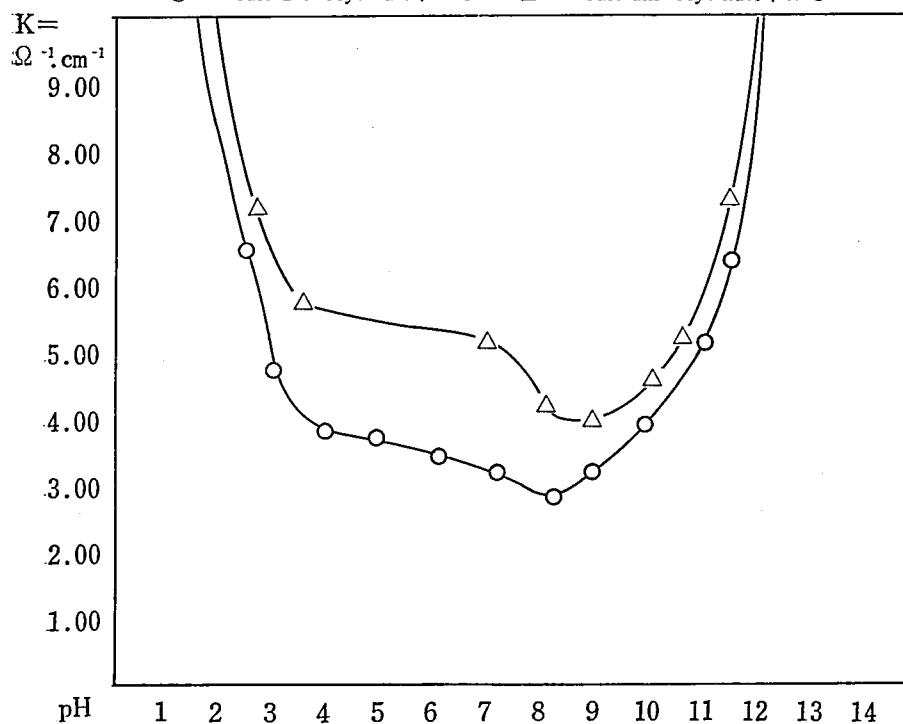


Fig. 3-5 Specific conductivity to pH of magnesium glycinate adduct.

○ — Magnesium+2EO △ — Magnesium Glycinate+6EO

From the above characteristics, it is very preferable to express the terms isoelectric zone than naming isoelectric point. Adduct of alkali earth metallic salt of magnesium and calcium had narrower isoelectric zone than of alkali salt.

This reaction was inferred from close connection of the difference of electric activity of calcium and magnesium in an aqueous solution.

1:1 adduct was thought to be sodium N-2-hydroxyethyl glycinate $\text{HOCH}_2\text{CH}_2\text{NHCH}_2\text{COONa}$ in base side of sodium hydroxide solution and N-2-hydroxyethyl glycine hydrochloride $\text{HOCH}_2\text{CH}_2\text{NHCICH}_2\text{COOH}$ in acid side of hydrochloric acid.

But it may be estimated to be linked to form six membered lactone compound.

From the measurement of conductivity that showed symmetrical wide U type curve to pH variation, intermolecular structure of $[\text{OCH}_2\text{CH}_2\text{NHCH}_2\text{C}] = \text{O}$ lactone could not be thought.

The author is grateful to Mr. H. Takebayashi and Mr. Y. Matuda for this experiments. And we would like to thank for the measurement of NMR spectra by Japan Electric Optical Laboratory Co., Ltd.

- 1) This paper is named as the studies on amphoteric surfactant I.
- 2) A part of this studies was presented at the 28th Annual Spring-Convention of the Chemical Society of Japan held in Tokyo 1973 by H. Hidaka and so on.
- 3) Maekawa and S. Tsumura *Bull. Agr. Chem. Soc. Japan* 20 101-105 (1956)
- 4) E. Ulsperger *Fette Seifen Anstrichmittel* 68 Jahrgang Nr. 11 964 (1966)
- 5) M. Maurice Pascal *Compt. Rend* 245 1318 (1957)
- 6) Ger. Offen 1. 956, 197, 09 Jun 1971, Appl. 07 Nov 1969; 8pp *Chem. Abstr.* 75 224 (1971)
- 7) G. Zweig and J. R. Whitaker "Paper Chromatography and Electrophoresis," Vol. 11 p. 110 Academic Press, New York, N. Y. (1971).
- 8) Y. Ishikawa, S. Hara C. Furuya and Y. Nakazawa. "Hakuso Kuromatogurafi," p. 151 Nanzando Press, Tokyo, Japan. (1972).