The Storage Stability of Metal Particle Media

Chemical analysis & kinetics of lubricant & binder hydrolysis

Kazuko Hanai & Yutaka Kakuishi

Research & Development Center,

Recording Media Products Div.,

Fuji Photo Film Co.Ltd.

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1 Introduction

- Some of old “Open reel MT” and “3480 cartridge” caused adhesion because of the hydrolysis of ester linkage of polyurethane(PU) as a binder.
- The life of MP tapes can be limited by the degradation of the binder and the lubricant rather than the oxidation of the magnetic particles.

⇒We decided to investigate the changes of organic compounds which have ester linkage in a MP tape.

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Main points

- Analyzed the hydrolysis of fatty acid ester and PU as first-order reaction and the reaction rates.
- Estimated the thickness of fatty acid ester on the surface of the magnetic layer and the concentration of fatty acid ester dissolved in the binder.
- Confirmed Fujifilm's MP tape has a good durability performance even after storage of 14 years.

2 Experimental

- **Sample**

The MP tape that has been produced for M2 and DLT3 more than 14 years since 1987.

- **Lubricants(Two types of fatty acid ester*)**

ester A; isoamyl stearate

ester B; buthoxyethoxyethoxy stearate

- **Binder;polyester*-polyurethane(PU)**

***Ester linkage is susceptible to hydrolysis.**

RCOOR' + H2O ⇔ RCOOH + R'OH

(ester) (water) (acid) (alcohol)

Analysis

Magnetic tapes stored over 14 years in a laboratory

Lubricants(Fatty acid esters)

Extraction using n-hexane

⇒Analysis by Gas Chromatography(GC)

(separation and quantitative analysis)

Binder(Polyester polyurethane)

Extraction using tetrahydrofuran

⇒Analysis by Gel Permeation Chromatography(GPC with UV detector)

(molecular number and quantitative analysis of soluble PU)

3 The decay of the fatty acid esters

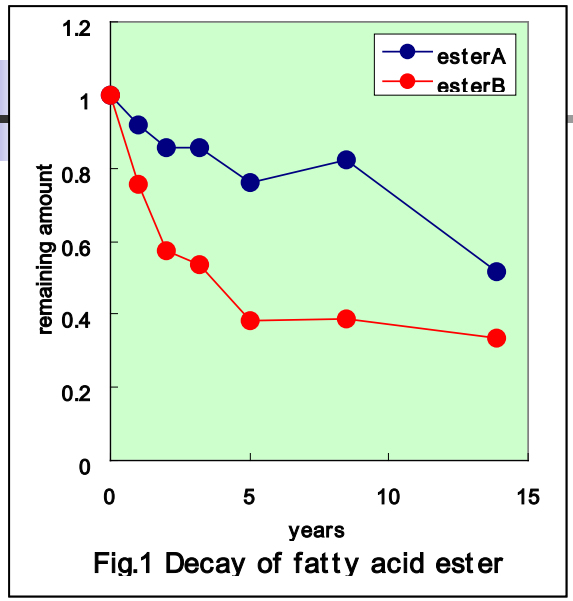

Fig.1 Decay of fatty acid ester

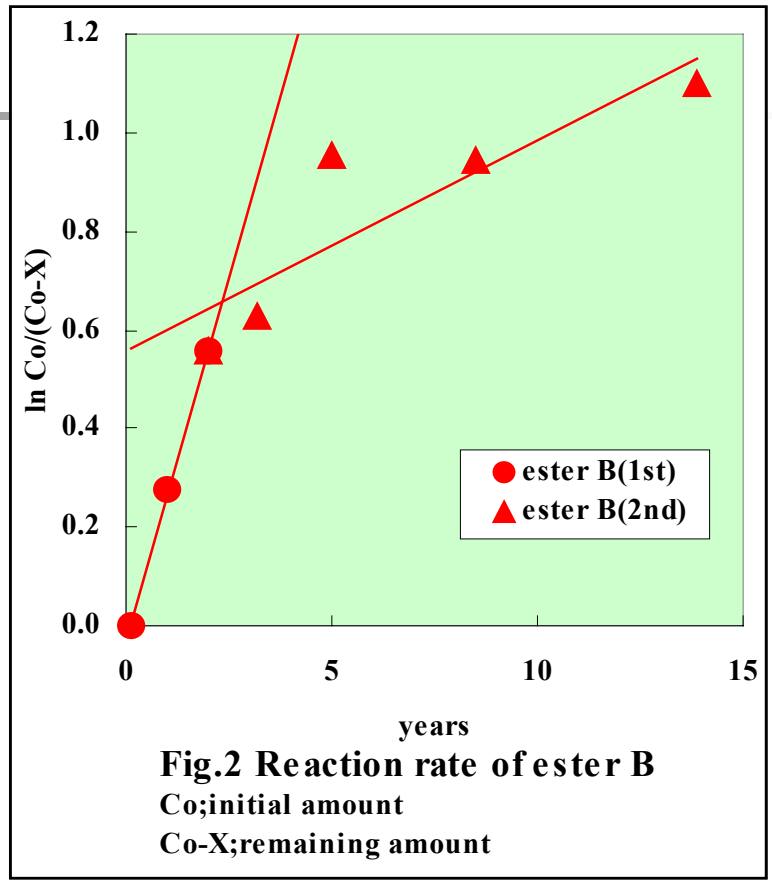

Fig.2 Reaction rate of ester B
Co;initial amount
Co-X;remaining amount

- **Decay reactions are expressed as two first-order reactions.**

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The decay rate constants and the meaning of two steps

Tab.1 The decay rate constant and rate ratio of fatty acid esters

	1st(/sec)	2nd(/sec)
ester A	2.6E-09	1.2E-09
ester B	9.3E-09	1.3E-09
ester B/ester A rate ratio	3.6	1.1
ester B/ester A rate ratio in acetone solution made weak acidic by HCl	3.1	

- In the first step,the hydrolysis reaction is dominant.
- In the second step,the vaporization is involved.

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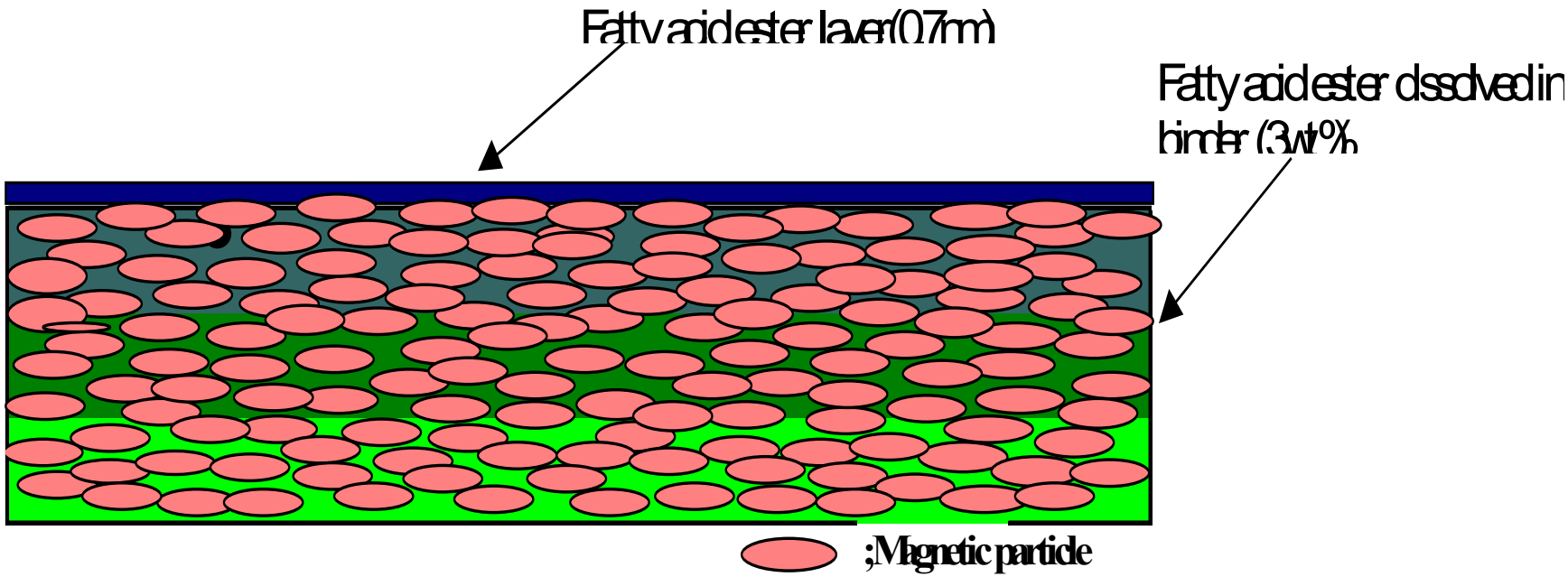
Model of a typical magnetic layer



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4 The hydrolysis of the polyester-polyurethane(PU)

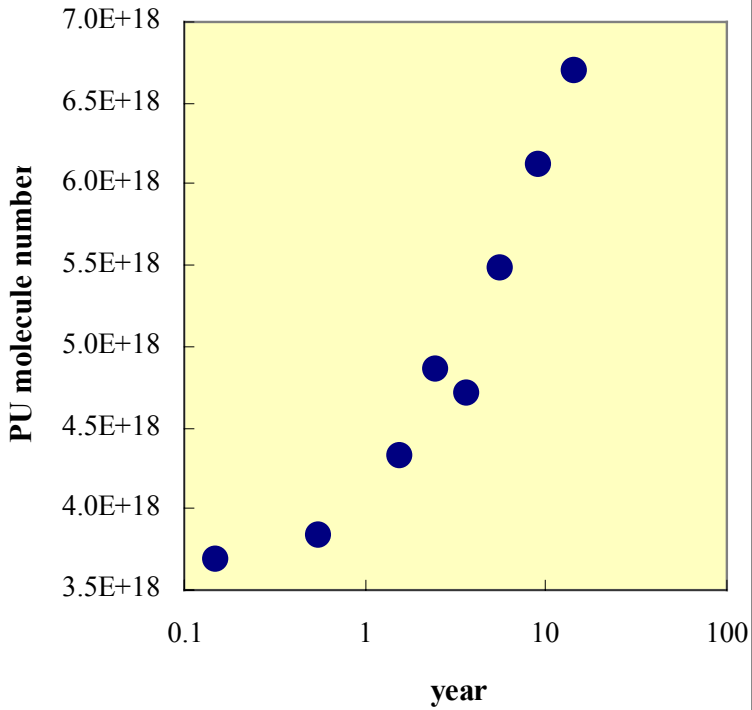

Fig.3 Molecule Number of Soluble PU
extracted from magnetic layer 1g

- The number of soluble PU molecules increases after two years, and hydrolysis reaction becomes predominant.

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The hydrolysis reaction rate of PU

Tab.2 The Decay Rate of PU

/sec
4.3E-11

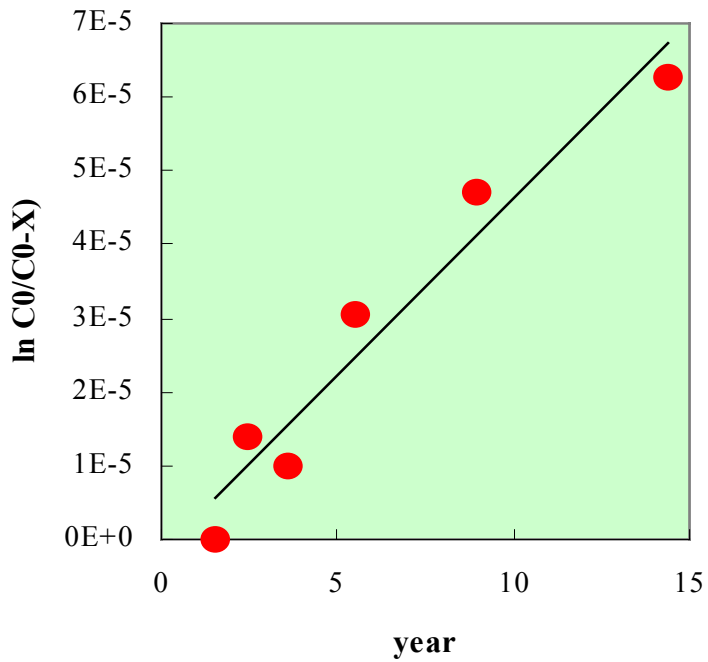

Fig.4 Reaction Rate of PU Degradation
C_0;total ester linkage number in PU
X;ester linkage number broken
(=increased molecule number)

- The hydrolysis reaction of PU can be shown as a first order reaction.
- The reaction rate of PU is extremely slow compared to the fatty acid esters.

5 Physical characteristics and durability

Tab.3 Changes of properties of MP tape after fourteen years

Storage time(years)	0	14
Magnetic properties		
Br(Gauss)	2,640	2,320
Mechanical properties		
Tg of magnetic layer (℃)	82	82
Friction coefficient	0.22	0.31
Video output(dB)	0	-0.6

- This MP tape keeps its good performance after long-term storage.

The comparison with latest MP(D5HD)

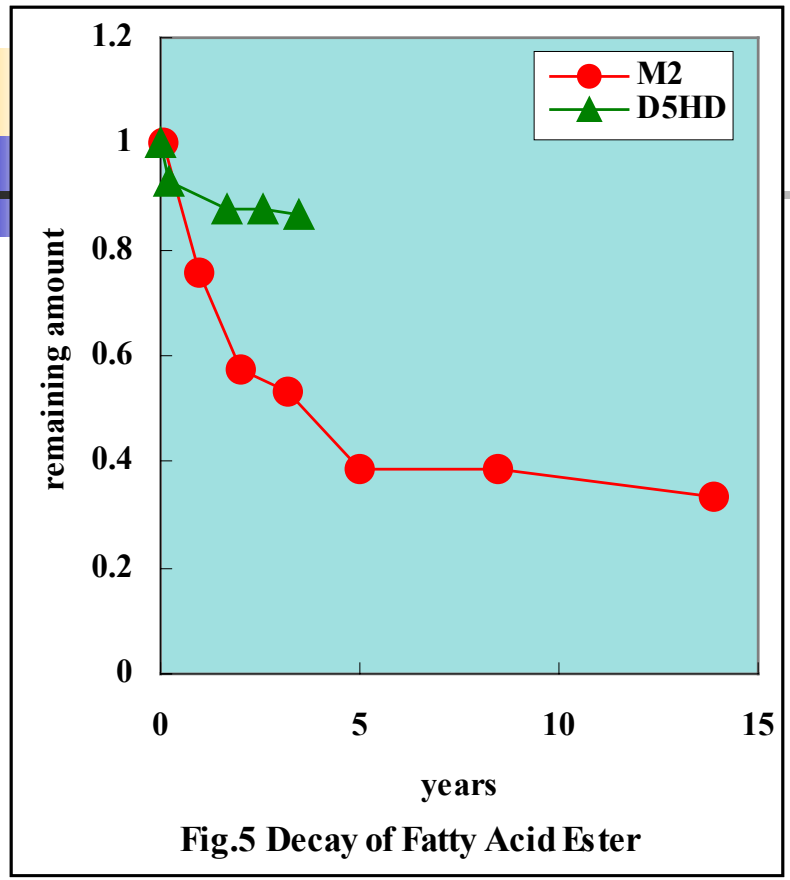

Fig.5 Decay of Fatty Acid Ester

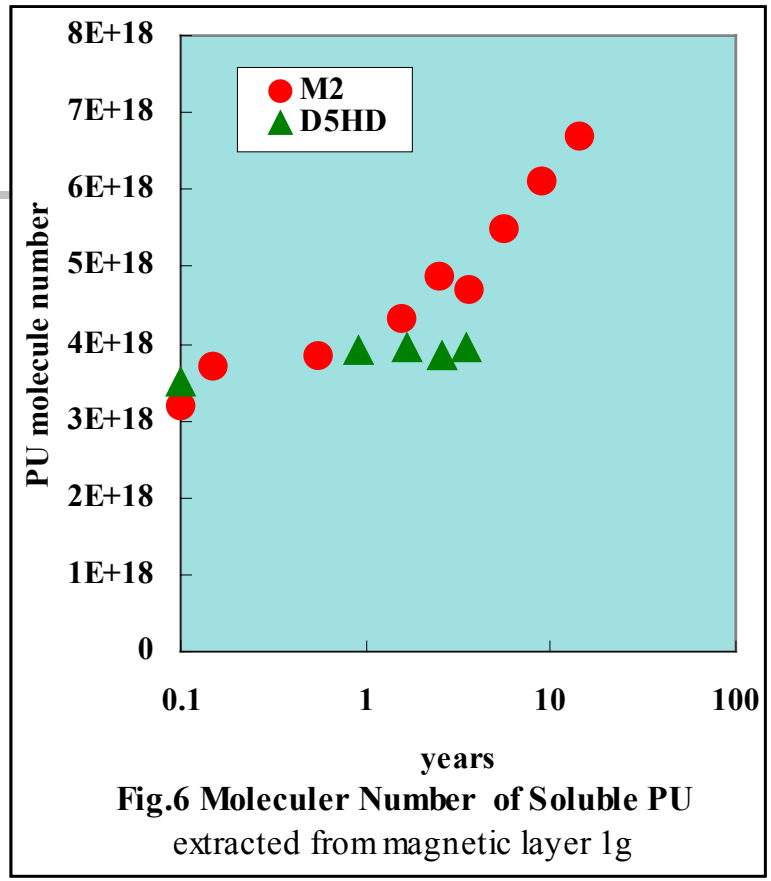

Fig.6 Moleculer Number of Soluble PU
extracted from magnetic layer 1g

- The storage stability of D5HD tape is further improved compared with M2 tape.

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Main results and conclusion

- **Fujifilm's MP is stable enough after actual storage for 14 years and Fujifilm's latest MP shows more stable characteristics.**
- Described the hydrolysis reactions of lubricant and binder in the MP tape as first-order reactions and calculated the reaction rates.
- Estimated the thickness of fatty acid ester on the surface of the magnetic layer and the concentration of fatty acid ester dissolved in the binder.

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