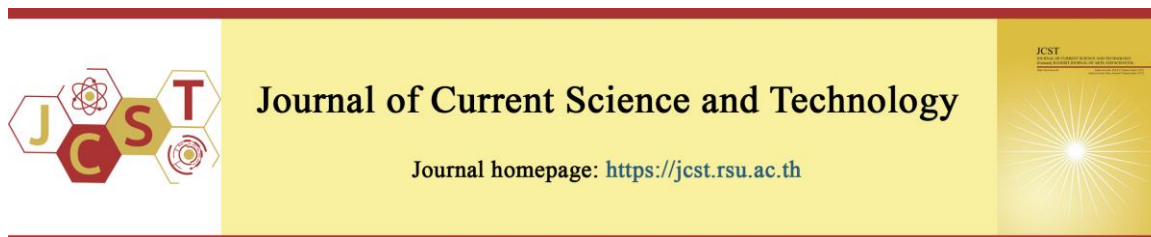


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Polyester That is Degradable by Sodium Bicarbonate After Oxidation of Sulfide to Sulfone: Polyester from Glyceraldehyde Ethylene-Thioacetal

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Abstract

Polyesters bearing the 2-thioethyl ester moiety degrade through oxidation to sulfone followed by β -elimination promoted by a base. The basicity of sodium carbonate is essential for the β -elimination process, while degradation using sodium bicarbonate has proven unsuccessful. To achieve highly selective degradation, novel polyesters were developed in which sodium bicarbonate can promote the β -elimination process. A thioacetal of glyceraldehyde was synthesized as the monomer for the preparation of a model ester and of polyesters. The model diester was prepared by reaction with benzoyl chloride. Quantitative oxidation of the model diester to the bis-sulfone and subsequent β -elimination using sodium bicarbonate solution were monitored by $^1\text{H-NMR}$ spectroscopy. Polyesters were synthesized through reactions with terephthaloyl chloride and isophthaloyl chloride. The oxidative degradation of these polyesters was successfully carried out via oxidation followed by treatment with sodium bicarbonate solution.

Keywords: β -elimination, glyceraldehyde, oxidative degradation, polyester, sodium bicarbonate, sulfone, thioacetal

1. Introduction

Degradable polymers have garnered significant attention for promoting the recycling and disposal of polymeric materials. Although polyester can be degraded through hydrolysis or alcoholysis (alcohol-exchange reaction) of the ester group, harsh reaction conditions are required to complete the process (El Darai et al., 2024). Consequently, polyesters with reactive ester groups have been proposed as degradable alternatives (Banno et al., 2026; Buensoz et al., 2024; Kint et al., 2001; Molina et al., 2026; Weinberg et al., 1998; Zheng et al., 2025). However, highly reactive polyesters that degrade in response to a natural stimulus such as water tend to exhibit low

reliability during use, as reactivity and reliability are generally incompatible. It is important to note that chemical and thermal stability are essential for the practical application of polymers.

To address the conflicting requirements for degradable polymers, we have proposed a two step degradation approach: a stable functional group in the polymer backbone is converted into a highly reactive one, allowing for rapid degradation of the resulting polymer. If a non-natural stimulus is required for the functional group conversion, high reliability during use and high degradability after use can be achieved (Figure 1a).

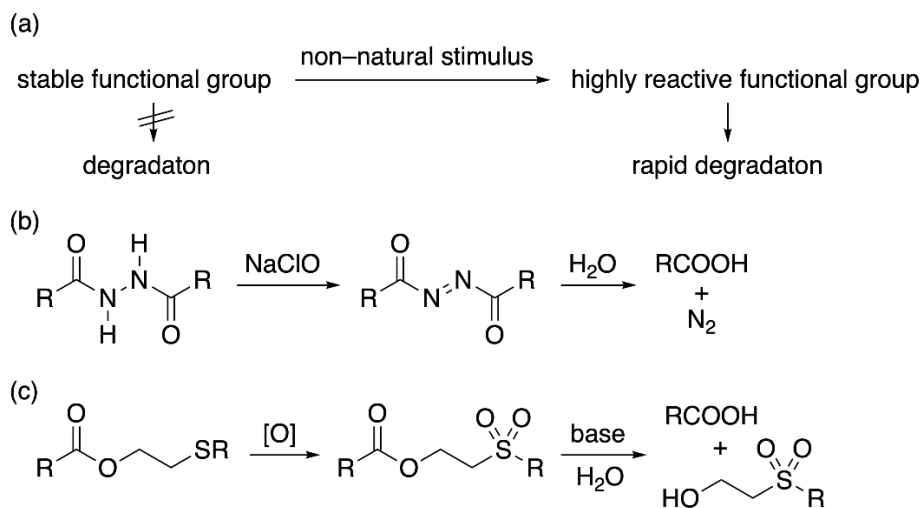


Figure 1 (a) Design of highly reliable degradable polymer, (b) oxidative degradation of diacylhydrazine, (c) oxidative degradation of 2-thioethyl ester

A successful example of this two-step degradation approach is poly(diacylhydrazine) (Kihara et al., 2007; Kihara et al., 2008; Nagashima et al., 2012). Diacylhydrazine, a diamide of hydrazine, is chemically and thermally stable. Although it is not oxidized by oxygen even at high temperatures, it can be rapidly oxidized by non-natural oxidants such as sodium hypochlorite (Wongwailikhit et al., 2024). The resulting diacyldiimide is a highly reactive functional group that undergoes rapid hydrolysis to quantitatively form carboxylic acid (Figure 1b). While poly(diacylhydrazine) is a highly reliable polymer, it undergoes rapid oxidative degradation when treated with sodium hypochlorite solution. Oxidatively degradable epoxy resin (Oguri et al., 2016) and superabsorbent polymer (Yanaze & Kihara, 2021) have also been developed as polymeric materials that can be removed or solubilized after use. Additionally, the undamaged recovery of expensive carbon fiber sheets from carbon fiber-reinforced polymer has been reported (Yanaze & Kihara, 2025).

Another class of oxidatively degradable polymer is poly(2-thioethyl ester) (Kihara et al., 2026). Although 2-thioethyl ester is a non-reactive ester, the oxidation of the sulfide group to sulfone enhances the acidity of the α -proton, facilitating β -elimination (Figure 1c) (Hardy et al., 1968; Inoue et al., 1994). Because sulfide is not oxidized by oxygen even at high temperatures, polyesters bearing 2-thioethyl

ester are reliable during use. However, sulfide can be rapidly and quantitatively oxidized to sulfone by non-natural oxidants such as peracids. The resulting polyester undergoes facile base-promoted β -elimination, degrading to the corresponding carboxylic acid. At a minimum, the basicity of sodium carbonate is necessary for β -elimination, while degradation using sodium bicarbonate has proven unsuccessful.

Because β -elimination is generally more rapid than hydrolysis or alcoholysis, selective degradation of 2-thioethyl ester is feasible. However, under certain conditions, sodium carbonate can also promote hydrolysis or alcoholysis. Therefore, to fully protect ester groups other than 2-thioethyl ester from degradation, the β -elimination process must be conducted using sodium bicarbonate, which has insufficient basicity to promote hydrolysis or alcoholysis of the ester group.

As a variation of 2-thioethyl ester, 1,3-dithian-2-ylmethyl (Dim) ester has been reported (Figure 2) (Kunz & Waldmann, 1983; Waldmann & Kunz, 1988). Dim ester is degradable under very weakly basic conditions after oxidation to sulfone because the α -proton of bis-sulfone is doubly activated. However, the corresponding polyester has not yet been reported. Further, while the degradation of Dim ester has been promoted by pH control, the use of sodium bicarbonate has not been documented.

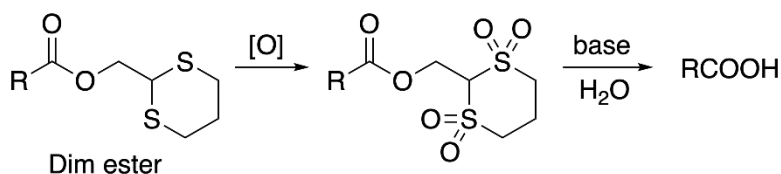


Figure 2 Oxidative degradation of Dim ester

2. Objectives

The objective of this study is to develop polyesters that are degradable through oxidation followed by treatment with sodium bicarbonate. Based on the strategy involving Dim ester, the sulfide group in 2-thioethyl ester was replaced with a thioacetal moiety. After oxidizing the thioacetal to bis-sulfone, degradation using sodium bicarbonate was examined, and the details of the oxidative degradation reaction were investigated.

3. Materials and Methods

3.1 General

NMR spectra were recorded on JEOL JNM-ECA400 or JEOL JNM-ECZ600 spectrometers. GPC was performed using a Shimadzu LC-10AT system with a TOSOH TSKgel® GMHHR-M column placed in a CTO-20A oven equipped with RID-10A and SPD-10AV detectors and a DGU-12A on-line degasser. DMF was used as the eluent for the GPC analysis.

3.2 Materials

All chemicals were of reagent grade and were used without further purification.

3.3 Glyceraldehyde Thioacetal GET via Thioacetalization

A mixture of 194.5 mg (1.18 mmol) of glyceraldehyde diethyl acetal (**1**), 201.9 mg (2.14 mmol) of ethane-1,2-dithiol (**2**) and 0.030 mL (0.10 mmol) of $\text{BF}_3 \cdot \text{OEt}_2$ in dichloromethane (12 mL) was stirred under an argon atmosphere at room temperature for 24 h. After a saturated aqueous sodium bicarbonate solution (5 mL) was added, the mixture was extracted with dichloromethane. To the organic layer, a 0.5 wt% aqueous copper (II) sulfate solution (50 mL) was added, and the resulting precipitate was filtered off through celite. The aqueous layer was separated and extracted with dichloromethane. The combined organic layers were dried over anhydrous sodium sulfate and evaporated under reduced pressure. The residue was purified by silica gel column chromatography (eluent: ethyl

acetate-hexane, 2:1, v/v) to obtain 67.1 mg (33%) of glyceraldehyde thioacetal **GET** as a colorless oil.

^1H NMR (CDCl_3 , 400 MHz): δ 4.57 (d, $J = 7.6$ Hz, 1H), 3.83 (ddd, $J = 11.3, 6.8, 3.4$ Hz, 1H), 3.70-3.63 (m, 1H), 3.62-3.56 (m, 1H), 3.31-3.15 (m, 4H), 2.81 (d, $J = 3.9$ Hz, 1H), 2.01 (dd, $J = 6.7, 5.9$ Hz, 1H) ppm.

3.4 *O*-Isopropylidene-glyceraldehyde 3

To a solution of 6.0280 g (23.0 mmol) of 1,2:5,6-di-*O*-isopropylidene-D-mannitol (**4**) in dichloromethane (60 mL), a saturated aqueous sodium bicarbonate solution (3 mL) and 7.4089 g (34.6 mmol) of sodium periodate were added. After stirring vigorously at room temperature for 2 h, the mixture was dried over anhydrous magnesium sulfate and evaporated under reduced pressure to obtain 5.3789 g (96%) of *O*-isopropylidene-glyceraldehyde (**3**) as a colorless oil.

^1H NMR (CDCl_3 , 400 MHz): δ 9.73 (d, $J = 1.9$ Hz, 1H), 4.39 (ddd, $J = 7.5, 4.8, 1.9$ Hz, 1H), 4.18 (dd, $J = 8.9, 7.5$ Hz, 1H), 4.11 (dd, $J = 8.9, 4.8$ Hz, 1H), 1.50 (s, 3H), 1.43 (s, 3H) ppm.

3.5 *O*-Isopropylidene-glyceraldehyde Thioacetal 5

To a solution of 945.0 mg (7.26 mmol) of **3** and 838.5 mg (8.90 mmol) of **2** in toluene (50 mL), 2.0492 g of montmorillonite KSF was added, and the mixture was refluxed for 17 h while removing water with a Dean-Stark apparatus. After the insoluble material was filtered off through celite, the filtrate was evaporated under reduced pressure. The residue was purified by silica gel column chromatography (eluent: ethyl acetate-hexane, 1:20, v/v) to obtain 599.8 mg (40%) of *O*-isopropylidene-glyceraldehyde thioacetal (**5**) as a pale-yellow oil.

^1H NMR (CDCl_3 , 400 MHz): δ 4.51 (d, $J = 5.3$ Hz, 1H), 4.16-4.11 (m, 2H), 3.83-3.79 (m, 1H), 3.26-3.20 (m, 4H), 1.46 (s, 3H), 1.36 (s, 3H) ppm.

3.6 Glyceraldehyde Thioacetal GET via Hydrolysis

To a solution of 2.4585 g (11.9 mmol) of **5** in THF (10 mL), water (5 mL) and one drop of trifluoroacetic acid were added, and the mixture was

refluxed for 24 h. Additional water (10 mL) and three drops of trifluoroacetic acid were added, and the mixture was refluxed for 2 h. After evaporation under reduced pressure, the residue was purified by silica gel column chromatography (eluent: dichloromethane-methanol, 9:1, v/v) to obtain 1.6349 g (83%) of **GET** as a pale-yellow oil.

¹H NMR (CDCl₃, 400 MHz): δ 4.56 (d, *J* = 7.6 Hz, 1H), 3.83 (ddd, *J* = 11.3, 6.6, 3.4 Hz, 1H), 3.70-3.63 (m, 1H), 3.62-3.56 (m, 1H), 3.31-3.15 (m, 4H), 2.89 (d, *J* = 3.9 Hz, 1H), 2.13 (t, *J* = 6.1 Hz, 1H) ppm.

3.7 Model Diester Bz₂GET

To a solution of 325.4 mg (1.96 mmol) of **GET** and 0.70 mL (8.67 mmol) of pyridine in dichloromethane (5 mL), a solution of 976.1 mg (6.94 mmol) of benzoyl chloride in dichloromethane (3 mL) was added under an argon atmosphere at 0°C, and the mixture was refluxed for 18 h. The mixture was washed with water, and the aqueous layer was extracted with dichloromethane. The combined organic layers were dried over anhydrous magnesium sulfate and evaporated under reduced pressure. The residue was purified by silica gel column chromatography (eluent: dichloromethane-hexane, 1:1, v/v) to obtain 419.8 mg (57%) of model diester **Bz₂GET** as a white solid.

¹H NMR (CDCl₃, 600 MHz): δ 8.07-8.04 (m, 4H), 7.59-7.53 (m, 2H), 7.47-7.40 (m, 4H), 5.48 (ddd, *J* = 5.5, 3.9, 2.0 Hz, 1H), 4.89 (d, *J* = 5.5 Hz, 1H), 4.79 (dd, *J* = 8.0, 2.0 Hz, 1H), 4.65 (dd, *J* = 8.0, 3.9 Hz, 1H), 3.35-3.22 (m, 4H) ppm.

3.8 Oxidative Degradation of Bz₂GET

To a solution of 22.1 mg (0.0745 mmol) of **Bz₂GET** in CDCl₃ (2.0 mL), 137.3 mg (purity 70 wt%, 0.557 mmol) of mCPBA was added, and the progress of oxidation was monitored by ¹H-NMR spectroscopy. After 6 h, 94.8 mg (1.13 mmol) of sodium bicarbonate and water (0.50 mL) were added, and the progress of the degradation was monitored by ¹H-NMR spectroscopy. After 5 h, 3 M hydrochloric acid (2 mL) was added, and the mixture was extracted with dichloromethane. The aqueous layer was evaporated under reduced pressure, and the residue was dissolved in methanol. After the insoluble material was filtered off, the filtrate was evaporated under reduced pressure.

3.9 Polyester TPET

To a solution of 510.0 mg (3.067 mmol) of **GET** and 622.8 mg (3.067 mmol) of terephthaloyl

chloride in dichloromethane (3 mL), 1.0 mL (12 mmol) of pyridine was added dropwise under an argon atmosphere at 0°C. After stirring for 3 d, dichloromethane (15 mL) was added, and the slurry was poured into 300 mL of methanol with vigorous stirring. The precipitate was collected by filtration, washed with methanol, and dried under reduced pressure to obtain 975.2 mg (107%) of crude polyester as a white solid. The crude polyester was ground in a mortar, dispersed in dichloromethane (15 mL), and poured into 350 mL of methanol with vigorous stirring. The precipitate was collected by filtration, washed with methanol, and dried under reduced pressure to obtain 0.7893 g (87%) of polyester **TPET** as a white solid.

3.10 Polyester IPET

To a solution of 498.8 mg (3.00 mmol) of **GET** and 610.4 mg (3.00 mmol) of isophthaloyl chloride in dichloromethane (3 mL), 1.0 mL (12 mmol) of pyridine was added dropwise under an argon atmosphere at 0°C. After stirring for 48 h, dichloromethane (10 mL) was added, and the reaction mixture was poured into 300 mL of methanol with vigorous stirring. The precipitate was collected by filtration, washed with methanol, and dried under reduced pressure to obtain 736.1 mg (83%) of polyester **IPET** as a white solid.

3.11 Oxidative Degradation of TPET

To a suspension of 21.0 mg (0.0709 mmol) of **TPET** in CDCl₃ (3.0 mL), 70.3 mg (purity 70 wt%, 0.285 mmol) of mCPBA was added. After 24 h, 51.2 mg (0.609 mmol) of sodium bicarbonate and water (1.0 mL) were added. After 24 h, 3 M hydrochloric acid (2 mL) was added, and the mixture was extracted with dichloromethane. The aqueous layer was evaporated under reduced pressure, and the residue was dissolved in methanol. After the insoluble material was filtered off, the filtrate was evaporated under reduced pressure.

3.12 Oxidative Degradation of IPET

To a solution of 20.7 mg (0.0698 mmol) of **IPET** in CDCl₃ (3.0 mL), 70.2 mg (purity 70 wt%, 0.285 mmol) of mCPBA was added, and the progress of oxidation was monitored by ¹H-NMR spectroscopy. After 24 h, 50.7 mg (0.603 mmol) of sodium bicarbonate and water (1.0 mL) were added. After 24 h, 3 M hydrochloric acid (2 mL) was added, and the mixture was extracted with dichloromethane. The aqueous layer was evaporated under reduced pressure,

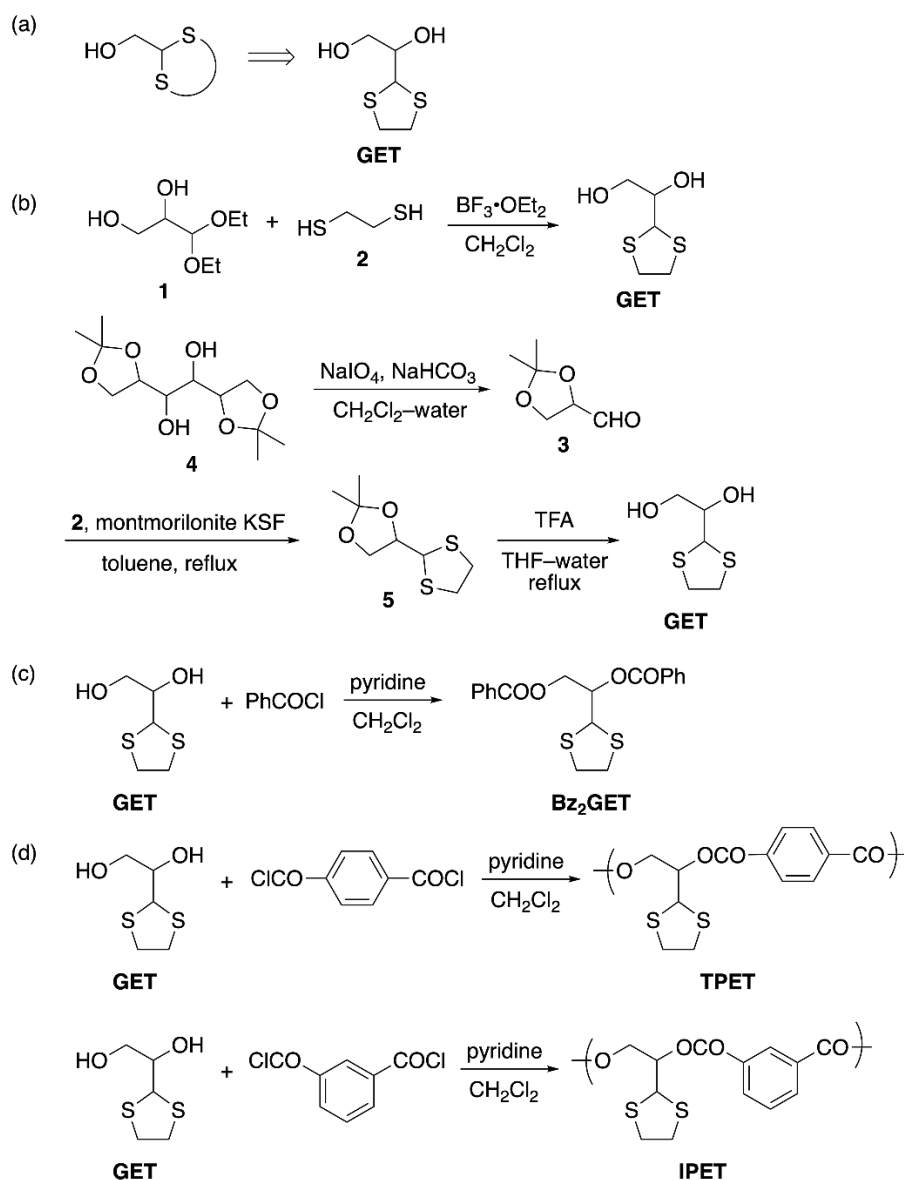
and the residue was dissolved in methanol. After the insoluble material was filtered off, the filtrate was evaporated under reduced pressure.

4. Results and Discussion

4.1 Diol Monomer Bearing Thioacetal Structure

Dim alcohol refers to the thioacetal of a 2-hydroxyaldehyde. Glyceraldehyde is the most straightforward diol bearing the 2-hydroxyaldehyde moiety. Dithiolane is the most accessible thioacetal. Therefore, glyceraldehyde ethylene-thioacetal **GET** was designed as the monomer diol (Figure 3a).

The acetal exchange reaction of commercially available glyceraldehyde diethyl acetal (**1**) with ethane-1,2-dithiol (**2**) catalyzed by $\text{BF}_3 \cdot \text{OEt}_2$ was examined (Banerjee & Laya, 2000; Hatch et al., 1978), resulting in the formation of **GET** in 33% yield (Figure 3b). Figure 4a shows the $^1\text{H-NMR}$ spectrum of **GET** with the assignments. Although several reaction conditions were investigated, the yield of **GET** was not improved. The acid-catalyzed dehydration of **1** accounts for the low yield of **GET**.



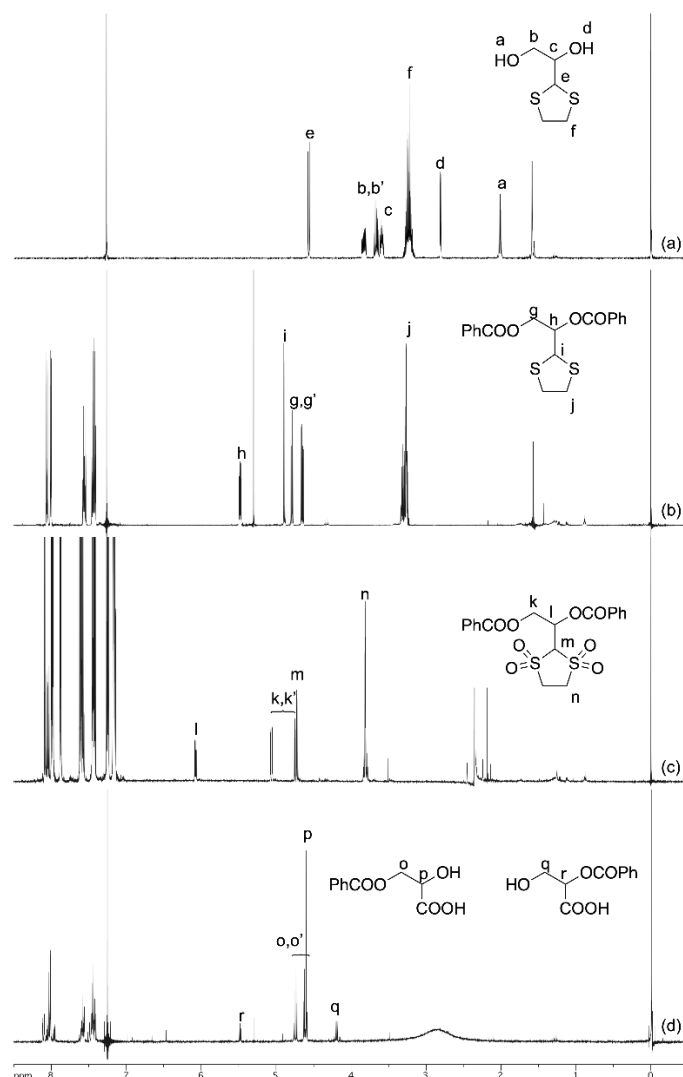


Figure 4 ^1H -NMR spectra (CDCl_3) of (a) **GET** (400 MHz), (b) **Bz₂GET** (400 MHz), (c) **Bz₂GETO₄** (600 MHz), (d) aliphatic degradation products (400 MHz)

The synthesis of **GET** from *O*-isopropylidene-glyceraldehyde (**3**), which was prepared from di-*O*-isopropylidene-D-mannitol (**4**) via a standard procedure (Ahrendt & Williams, 2004), was also investigated. When **3** was reacted with an excess of **2** in the presence of $\text{BF}_3 \cdot \text{OEt}_2$ as the acid catalyst, **GET** was formed via thioacetalization of the aldehyde to form the acetonide of **GET** (**5**) followed by a consecutive acetonide exchange reaction. However, the yield of **GET** was only 3%, while **5** and 2,2-dimethyl-1,3-dithiolane (**6**) were obtained in 34% and 31% yields, respectively. Although **6** was formed via the acetonide exchange of **2** with **3** and/or **5**, the yield of **GET** was significantly lower than that of **6**, indicating the instability of glyceraldehyde produced

by the acetonide exchange with **3**. When the reaction of **3** and **2** was carried out in the presence of montmorillonite KSF as a solid acid-catalyst (Labiad & Villemin, 1989; Villemin et al., 1992), **5** was obtained in 40% yield along with a trace amount of **GET**, and the formation of **6** was not observed. The acetonide exchange was suppressed by the montmorillonite KSF catalyst.

Upon hydrolyzing **5** using TFA as the acid catalyst (Leblanc et al., 1986), **GET** was obtained in 83% yield without hydrolysis of the thioacetal moiety (Figure 3b). Although the synthesis of **GET** from the inexpensive **4** required a multi-step sequence, the overall yield was comparable to that of the single-step reaction from the more expensive **1**.

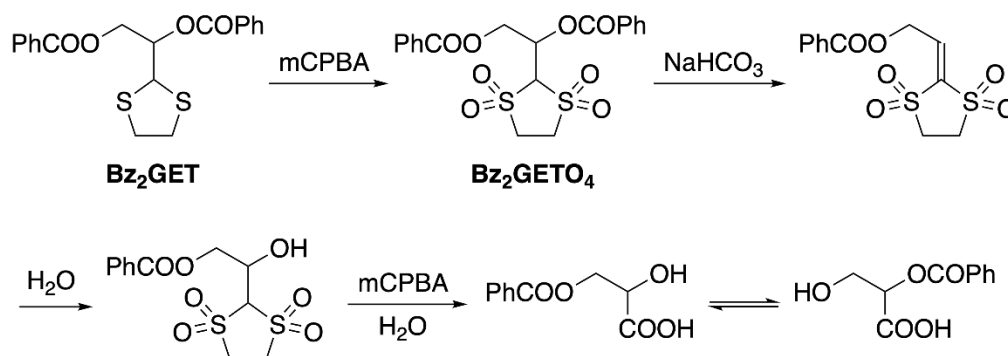


Figure 5 Estimated structures of the degradation products and the plausible reaction path to form them

4.2 Model Diester

To investigate the oxidative degradation behavior of the polyester prepared from **GET**, benzoate **Bz₂GET** was synthesized as the model diester. Following a standard procedure, **GET** was reacted with benzoyl chloride in the presence of pyridine to obtain **Bz₂GET** in 57% yield (Figure 3c).

The oxidation of **Bz₂GET** was carried out using mCPBA (Simpkins, 1993) as the oxidant in CDCl₃, and was monitored by ¹H-NMR spectroscopy (Figure 4b). The signals for **Bz₂GET** disappeared, and a new set of signals appeared (Figure 4c). The ester protons and the thioacetal ring protons shifted to a lower magnetic field, while the acetal proton shifted to a higher magnetic field. The ester methylene protons were observed as two separated dd peaks, indicating that there was only one chiral center in the product. Therefore, both sulfur atoms in **Bz₂GET** were completely oxidized to sulfone to produce bis-sulfone **Bz₂GETO₄**.

Subsequently, an aqueous solution containing 2 equivalents of sodium bicarbonate was added to the CDCl₃ solution of **Bz₂GETO₄**. All ¹H-NMR signals in the CDCl₃ layer disappeared, indicating that **Bz₂GETO₄** decomposed due to the action of sodium bicarbonate to form water-soluble products. The reaction mixture was then acidified with hydrochloric acid and extracted with dichloromethane. A mixture of benzoic acid and 3-chlorobenzoic acid was obtained, although no aliphatic signals were observed in the ¹H-NMR spectrum of the extract, indicating that the aliphatic compounds derived from **GET** were highly water-soluble. To identify the degradation products, the solvent was removed from the aqueous layer, and the residue was extracted with methanol. The ¹H-NMR spectrum of the methanol-soluble

products is shown in Figure 4d. The signal at 3.6 ppm corresponding to the cyclic bis-sulfone moiety of **Bz₂GETO₄** was not observed, and all signals appeared as dd. These observations indicated that the bis-sulfone moiety was hydrolyzed and oxidized to carboxylic acid under the reaction conditions after the addition of water to the β-elimination product. Two products were observed, probably owing to acyl-migration in the 1,2-diol system. The estimated structures of the degradation products and the plausible reaction pathway to form them are shown in Figure 5.

4.3 Polyester

The polycondensation of **GET** and terephthaloyl chloride was carried out using dichloromethane as the solvent and pyridine as the base (Figure 3d). Polyester **TPET**, which can be referred to as cyclic thioacetal-modified PET, was obtained as the methanol-insoluble fraction in 87% yield. **TPET** was insoluble in chloroform, dichloromethane, 1,1,2,2-tetrachloroethane, and HFIP, but soluble in DMSO, DMF, and DMAc. Consequently, **TPET** precipitated during the polymerization. Figure 6a shows the ¹H-NMR spectrum of **TPET**. Although all signals could be assigned to the structure of **TPET**, the integral values did not match those expected, indicating that an oligomer of **TPET** was obtained, and that the terminal groups affected the ¹H-NMR spectrum. The number-averaged molecular weight (*M_n*) of **TPET** could not be estimated from GPC analysis due to considerable tailing even when DMF was used as the eluent. The peak-top of the GPC profile corresponded to a molecular weight of 1,000 based on polystyrene standards.

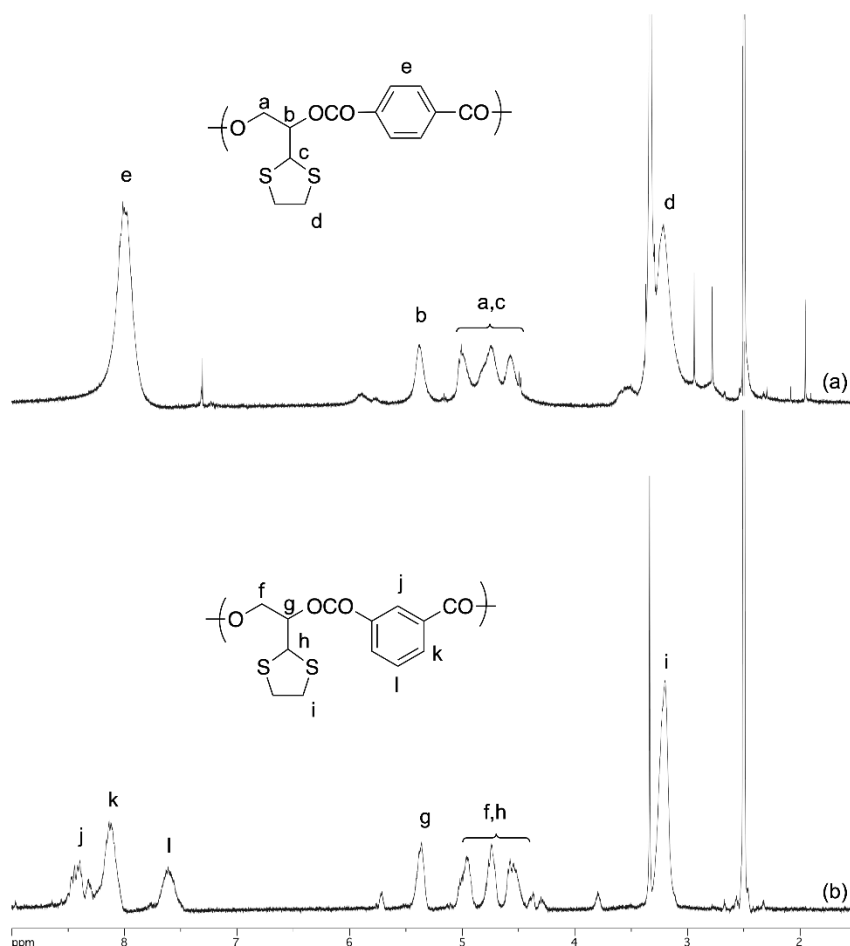


Figure 6 ^1H -NMR spectra (DMSO- d_6 , 400 MHz) of (a) **TPET** and (b) **IPET**

To increase the solubility of the polyester, a bent structure was introduced into the polyester backbone. Thus, isophthalic acid was used instead of terephthalic acid. The polycondensation of **GET** and isophthaloyl chloride was carried out (Figure 3d). The polyester **IPET** was obtained as the methanol-insoluble fraction in 83% yield. As expected, **IPET** was soluble in dichloromethane and chloroform. Figure 6b shows the ^1H -NMR spectrum of **IPET**. All signals could be assigned to the structure of **IPET**, and the integral values matched the expected structure. Due to slight tailing, the M_n of **IPET** could not be estimated from GPC, although the peak-top of the GPC profile was observed at a molecular weight of 1,500 based on polystyrene standards. Although the polymerization conditions were not optimized, higher molecular weights of **TPET** and **IPET** would be obtained if the polycondensation were conducted in a good solvent at a higher concentration.

The oxidative degradation of the polyesters was investigated. When a solution of **IPET** in chloroform was treated with excess mCPBA, the polymer precipitated due to conversion to sulfone. Sodium bicarbonate solution was then added to the mixture. The precipitate remained in the mixture. However, after the removal of solvents, the residue was soluble in methanol. Because **IPET** was insoluble in methanol, the polymer fraction was degraded to low-molecular-weight compounds. Therefore, oxidative degradation of **IPET** was achieved even with sodium bicarbonate as the base for β -elimination. From the result of oxidative degradation of **Bz₂GET**, it was expected that the degradation products were monomeric compounds, although the ^1H -NMR spectrum of the products was very complex, and the chemical structures of the products were not identified.

The oxidative degradation of **TPET** was also examined. A dispersion of **TPET** in chloroform was

treated with excess mCPBA, followed by sodium bicarbonate solution. The reaction mixture was soluble even in methanol, indicating the successful oxidative degradation of **TPET** using sodium bicarbonate. Both polyesters therefore underwent oxidative degradation under the mild conditions provided by sodium bicarbonate alone.

5. Conclusion

In this paper, we report polyesters that are degradable through oxidation followed by treatment with sodium bicarbonate. The thioacetal structure was the key to the β -elimination process using sodium bicarbonate after conversion to sulfone. The thioacetal of glyceraldehyde **GET** was found to be a very useful monomer for these polyesters. The conversion to sulfone and the β -elimination process were thoroughly monitored by ^1H -NMR spectroscopy. Because sodium bicarbonate is a very mild base, the polyesters reported in this paper are highly useful as oxidatively degradable materials that exhibit both high reliability during use and high degradability after use.

6. Acknowledgements

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7. Abbreviations

Abbreviation	Full Term
$\text{BF}_3 \cdot \text{OEt}_2$	Boron Trifluoride-Diethyl Ether Complex
CDCl_3	Chloroform- d_1
dd	Double Doublet
DMF	<i>N,N</i> -Dimethylformamide
GPC	Gel Permeation Chromatography
mCPBA	3-Chloroperbenzoic Acid
NMR	Nuclear Magnetic Resonance
TFA	Trifluoroacetic acid

8. CRediT Statement

Nobuhiro Kihara: Conceptualization, Methodology, Resources, Data Curation, Writing, Visualization, Supervision, Project Administration, Funding Acquisition.

Miho Honma: Validation, Formal Analysis, Investigation, Data Curation, Formal Analysis, Visualization, Writing – Review & Editing.

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