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# Glycerol-based thiolipids for model membranes

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An efficient synthesis of two glycerol-based thiolipids containing a neutral and flexible tetraethylene glycol chain with thiol and cyclic disulfide anchors for attachment onto a gold support is reported. Both synthesized products showed the ability to form tethered bilayer membranes.

**Key words:** tiolipid, tBLM, 1,2-ditetradecylglycerol

## INTRODUCTION

More than 50 years have passed since the lipid bilayer was accepted as the basic principle of the design for biological membranes. During this period, an enormous interest of membrane related processes pushed researchers to develop model systems and immobilize it onto a solid support to study numerous aspects of biomembrane structure and function [1–4]. The stability, flexibility and other properties made tethered bilayers one of the most promising model systems on a solid support which can be successfully investigated with a multitude of surface-sensitive analytical techniques for much biotechnological manipulation [5, 6].

Our working group continues searching and developing novel syntheses of different molecular systems suitable for modeling and research of tethered bilayer membranes (tBLM). The first step in the tBLM modeling process is preparation of a self-assembled monolayer (SAM) of thiolipids attached to the metal substrate [7]. The sulphur-gold bond is a commonly used chemisorption method for this purpose [8, 9]. Thiol molecules adsorb spontaneously from solution to a surface and form a highly reproducible, stable and densely packed monomolecular layer and its properties depend on temperature, duration of process, substrate, adsorbate, solvent nature and purity [10, 11]. The second step is fusion of liposomes prepared from phospholipids. Our main task was to synthesize derivatives for the first step.

We decided to begin our synthesis from popular glycerol-based thiolipids. Two compounds were made from the same parts as natural membrane lipids: a hydrophilic head group with a neutral spacer unit, hydrophobic tails and a linker – glycerol substructure that tethers two parts. There are many examples of analogous sulphur compounds with different functional group in literature [12, 13]. Unfortunately, thiol compounds are uncomfortable in use because of their ability to oxidize. However, we decided to synthesize thiol and cyclic disulfide with saturated long chains for the future possibility to compare their stability and suitability for tBLM modelling and research. We inserted polyethylene units because these inert groups are important components of specific-binding SAM and might be incorporated with a number of functional groups; what is more in the formation of model membrane, they serve as a spacer arm for tethering the lipid layer to the solid substrate [14, 15]. So, two new synthesized derivatives (Figure) consist of 1,2-ditetradecylglycerol (TDG) for embedding into a lipid bilayer, thiol and disulfide as a head group to attachment onto a gold support and tetraethylene glycol (TTEG) as a stable, flexible, neutral spacer unit to save the nature of embedding side. In addition, our novelty is in

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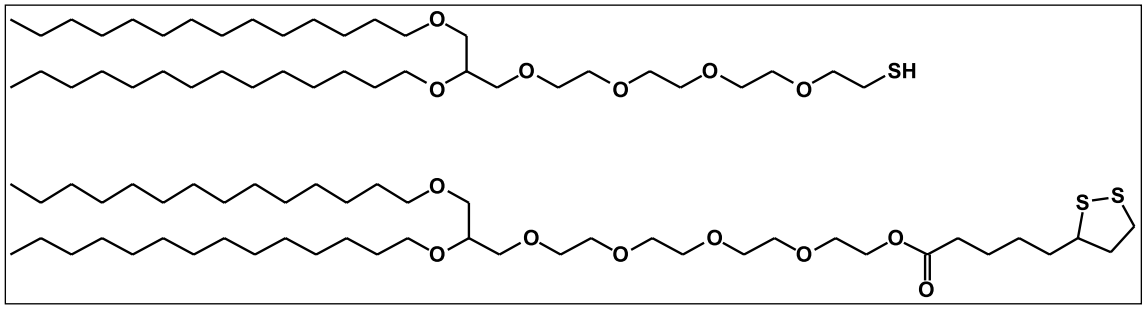


**Figure.** The structures of synthesized thiolipids

an interesting alternative synthesis route avoiding so popular amide and peptide bounds with possible hydrogen binding that is not acceptable during the tBLM formation process. Moreover, all reagents are inexpensive, commercially available and almost all products (5 from 6) were purified without column chromatography.

Both synthesized derivatives have analogues which are widely used for formation of drug delivery systems as cardiolipins [16], for investigation of integral membrane proteins and membrane related processes [17].

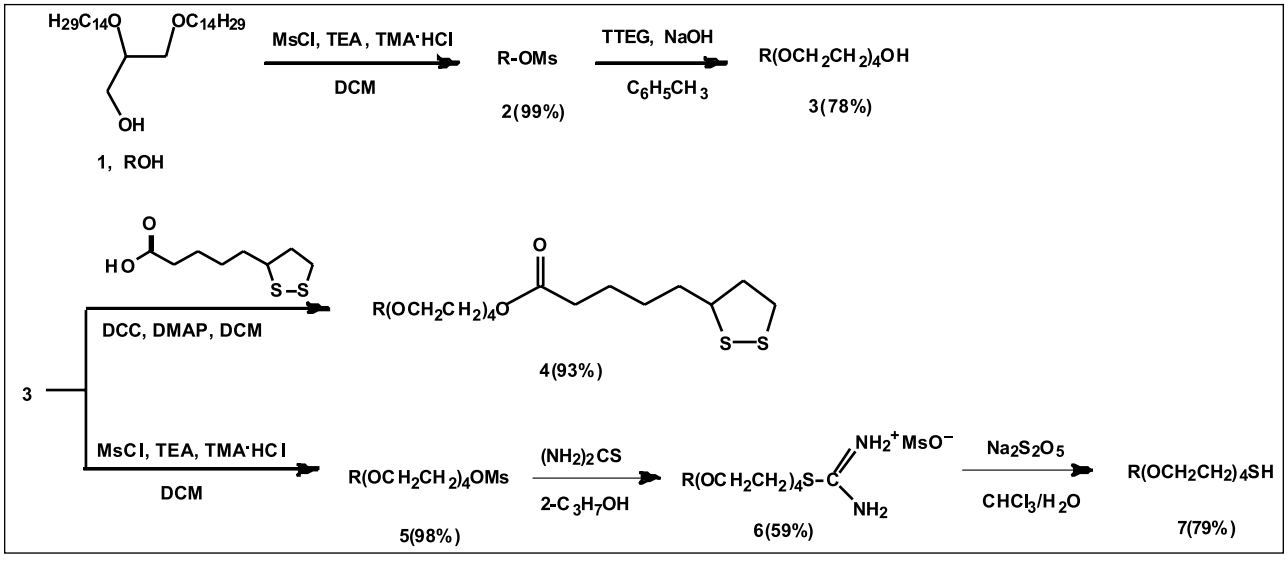
## RESULTS AND DISCUSSION

Diacylglycerols are very important in animal tissues, as they function as second messengers in many cellular processes, modulating vital biochemical mechanisms [18]. In spite of this fact, we join an alternative synthesis route with a neutral ether group in the neighborhood of 1,2-ditetradecyl glycerol instead of ester or amide bound. This will help to avoid possible hydrogen binding and save the nature of embedding lipid side during the farther formation of tBLM. For this purpose commercially available tetraethylene glycol was used. Thus, four ethylene groups provide unique properties, like more solubility in water, flexibility and low cytotoxicity [19] that is very attractive to tBLM formation.

McGilivray's working group reported [20] synthesis of similar thiolipid named WC14 for tBLM. Their synthesis route started from the allyl bromide and hexaethylene glycol coupling stage with farther free hydroxyl group protection and allyl's end oxidation. For this purpose the 3,4-dihydro-2H-pyran and osmium tetroxide were used, respectively. Final thiol was produced from bromide using thiolacetate. Atanasov et al. [21] proposed conversion of a double bond to a mercapto group using thioacetic acid and azobisisobutyronitrile. We suggest a new simpler way for the synthesis of analogue tiolipids. All components to our synthesis are inexpensive and commercially available. Moreover, all products, except compound **6** (Scheme), were purified without column chromatography in a good yield (59–99%).

The starting reagent – TDG (**1**) was synthesized by the working group of Linas Labanauskas from the Department of Organic Chemistry at the Center for Physical Sciences and Technology (Vilnius). It was produced from glycerol through benzylation of one primary hydroxyl group and farther simple substitution with 1-bromotetradecane and sodium hydride. Secondly, a deblocking procedure was made to give product **1**. There are some analogous examples in literature [22–23].

The route for the main thiolipids synthesis started from compound **3**, which was prepared by a method of two steps as shown in the Scheme.




**Scheme.** Synthesis route of thiolipids 2–7

Firstly, methanesulfonate **2** was prepared from TDG alcohol and methanesulfonyl chloride (MsCl) under the well-known [24–25] basic condition of tertiary amines (triethylamine – TEA, trimethylammonium monohydrochloride – TMA·HCl). It was found that the synthesis route depends on the humidity. The mesilation stage was made in a similar way in commercial dichloromethane (DCM) and under absolute conditions using a conversed Dean-Stark receiver. So, the reaction yield increased from 69 up 99%, respectively.

Secondly, TTEG was deprotonated in anhydrous toluene by sodium hydroxide and then reacted with compound **2**. This stage was repeated several times in benzene. However, product **3** was synthesized under reflux; it was noticed that reaction speed and yield depend on the solvent boiling point. In toluene (b. p. 111 °C) the reaction was finished after 3 hours, yielding 78% of alcohol **3**. The same conditions in benzene (b. p. 80.1 °C) allowed us to obtain 68% of the suspected product. Only triple reaction time made possible to increase the yield up to 80%.

Next, product **3** was coupled with N,N′-dicyclohexylcarbodiimide (DCC) activated lipoic acid in the presence of the catalytic amount of N,N′-dimethylpyridin-4-amine (DMAP). Reaction was made under nitrogen resulting in thiolipid **4** (93% yield) by an analogous example in literature [26].

Another direction of thiolipids synthesis was made by using mesyl thiuronium salt **6**, which was purified by column chromatography. The work experience of our working group [27] enabled to synthesize final thiol **7** by mild hydrolysis of sodium metabisulfite. This way was more effective (79% yield) than synthesis with a popular sodium hydroxide solution (58% yield).

Synthesized thiol **7** was self-oxidized to corresponding sulfate after two weeks standing at a freezer (–12 °C). Synthesized disulfide **4** was being kept under the same conditions without changes during several months. However, we recommend further keeping of these thiolipids under inert atmosphere of argon or nitrogen at low temperatures. Both synthesized final products **4** and **7** showed the ability to form tBLM. Firstly, mixed SAMs were made from mercaptoethanol and thiolipids solution (70 : 30) in methanol. Then, tBLMs were completed by incubating the mixed SAM surface with methanolic solutions of dioleoyl phosphatidyl choline (DOPC), which was afterward exchanged by a buffer. This process leads to the spontaneous formation of a bilayer.

## EXPERIMENTAL

All commercially available chemicals were used without further purifications, except freshly distilled and dried solvents. Nuclear magnetic resonance spectra were recorded in a $CDCl_3$ Varian Unity Inova NMR spectrometer ($^1H$ at 300 MHz; $^{13}C$ at 75 MHz) using the solvent signal as an internal standard. The IR spectra were recorded on the Perkin-Elmer FT-IR Spectrum BX II in KBr. Microanalyses were carried out on a Perkin-Elmer 2400-B microanalyser.

**2,3-bis(tetradecyloxy)propyl methanesulfonate (2)**
TDG (20.3 g, 41.9 mmol) and TEA (11.8 mL, 8.56 g, 84.6 mmol) were dissolved in DCM (120 mL) and refluxed in a three-neck round bottom flask equipped with a conversed Dean-Stark receiver for 2 hours. Then TMA·HCl (0.8 g, 8.3 mmol) was added and the mixture was cooled to 0 °C. Next, MsCl (6.49 mL, 9.59 g, 84 mmol) was dissolved in DCM (20 mL) and added dropwise to the stirred reaction mixture. It was stirred for 1 hour at room temperature and refluxed for 2 hours. After standing overnight at room temperature, it was washed with diluted sulfuric acid (1:200), sodium bicarbonate solution (10%) and water. The combined DCM extracts were dried ($Na_2SO_4$), filtered and evaporated to give 23.3 g (99%) of corresponding compound **2**, with the melting point 33–35 °C.

$^1H$ NMR ($CDCl_3$, δ ppm): 0.81–0.96 (m, 6H, $CH_2\underline{CH_3}$); 1.19–1.42 (br. s, 44H, $OCH_2CH_2(\underline{CH_2})_{11}CH_3$); 1.49–1.63 (m, 4H, $OCH_2\underline{CH_2}(CH_2)_{11}CH_3$); 3.04 (s, 3H, $OSO_2\underline{CH_3}$); 3.40–3.59 (m, 6H, $CHO\underline{CH_2}CH_2$ and $CH\underline{CH_2}O\underline{CH_2}CH_2$); 3.64–3.70 (m, 1H, $\underline{CH}$); 4.22–4.28 and 4.36–4.41 (m, 2H, $\underline{CH_2}OSO_2CH_3$).

$^{13}C$ NMR ($CDCl_3$, δ ppm): 14.11 ($CH_2\underline{C}H_3$), 22.68 ($\underline{C}H_2CH_3$), 25.98 ($CHCH_2OCH_2CH_2\underline{C}H_2$), 26.05 ($CHOCH_2CH_2\underline{C}H_2$), 29.35–29.90 (alkyl $\underline{C}H_2$), 31.91 ($\underline{C}H_2CH_2CH_3$), 37.35 ($OSO_2\underline{C}H_3$), 69.00 ($\underline{C}H_2OSO_2CH_3$), 69.73 ($CHO\underline{C}H_2CH_2$), 70.78 ($CH\underline{C}H_2OCH_2$), 71.85 ($CHCH_2O\underline{C}H_2$), 76.32 ($\underline{C}H$).

IR (KBr, υ $cm^{-1}$): 2956, 2919, 2850, 1467, 1342, 1186, 1128, 962.

Found, %: C, 68.11; H, 11.73; O, 14.05; S, 5.88. Anal. calcd. for $C_{32}H_{66}O_5S$ (562.93), %: C, 68.28; H, 11.82; O, 14.21; S 5.70.

**14-(tetradecyloxy)-3,6,9,12,16-pentaoxatriacontan-1-ol (3)**
TTEG (15.25 mL, 17.08 g, 88 mmol) and sodium hydroxide (1.407 g, 35.2 mmol) were dissolved in toluene (100 mL) and refluxed in a three-neck round bottom flask equipped with a Dean-Stark receiver for 2 hours. Then flask was cooled to 30 °C and compound **2** (9.9 g, 17.59 mmol) was added. The reaction mixture was refluxed for 3 hours. Then it was allowed to cool to room temperature and washed with water. The combined toluene extracts were dried ($Na_2SO_4$), filtered and evaporated, yielding 9.1 g (78%) of compound **3**.

$^1H$ NMR ($CDCl_3$, δ ppm): 0.86–0.91 (m, 6H, $\underline{CH_3}$); 1.24–1.35 (br. s, 44H, $OCH_2CH_2(\underline{CH_2})_{11}CH_3$); 1.53–1.59 (m, 4H, $OCH_2\underline{CH_2}(CH_2)_{11}CH_3$); 3.41–3.51 (m, 4H, $O\underline{CH_2}(CH_2)_{12}CH_3$); 3,53–3.63 (m, 5H, $\underline{CH_2CHCH_2}$); 3.64–3.67 (m, 14H, TTEG $O\underline{CH_2CH_2}O$); 3.71–3.74 (m, 2H, $\underline{CH_2}OH$); 7.19 (s, 1H, $\underline{OH}$).

$^{13}C$ NMR ($CDCl_3$, δ ppm): 14.08 ($\underline{C}H_3$), 22.66 ($\underline{C}H_2CH_3$), 26.08 ($CHCH_2OCH_2CH_2\underline{C}H_2$), 26.13 ($CHOCH_2CH_2\underline{C}H_2$), 29.33–30.10 (alkyl $\underline{C}H_2$), 31.91 ($\underline{C}H_2CH_2CH_3$), 61.74 ($\underline{C}H_2OH$), 70.23–72.53 (TTEG $O\underline{C}H_2\underline{C}H_2O$ and $\underline{C}H_2CH\underline{C}H_2$), 77.89 ($\underline{C}H$).

IR (KBr, υ $cm^{-1}$): 3448 (OH), 2955, 2918, 2851, 1725, 1468, 1372, 1350, 1300, 1249, 1117 (C-O), 942.

Found, %: C, 70.81; H, 11.93; O, 16.65. Anal. calcd. for $C_{39}H_{80}O_7$ (661.05), %: C, 70.86; H, 12.20; O, 16.94.

**14-(tetradecyloxy)-3,6,9,12,16-pentaoxatriacontyl 5-(1,2-dithiolan-3-yl)pentanoate (4)**

Compound **3** (1 g, 1.513 mmol) was dissolved in DCM (20 mL). Then lipoic acid (0.312 g, 1.513 mmol), DCC (0.2 g, 0.974 mmol) and DMAP (0.05 g, 0.409 mmol) were added. The reaction mixture was stirred for 48 hours at room temperature under nitrogen. Then it was filtered, washed with water, sodium bicarbonate solution (5%) and again with water. The combined DCM extracts were dried ($Na_2SO_4$), filtered and evaporated, yielding 1.2 g (93%) of corresponding product **4**.

$^1$H NMR ($CDCl_3$, δ ppm): 0.86–0.90 (m, 6H, $\underline{CH_3}$); 1.19–1.36 (br. s, 44H, $OCH_2CH_2(\underline{CH_2})_{11}CH_3$); 1.43–1.75 (m, 10H, $OCH_2\underline{CH_2}(CH_2)_{11}CH_3$ and $OCOCH_2\underline{CH_2}\underline{CH_2}\underline{CH_2}$); 1.85–1.96 (m, 1H, SCH-$\underline{H^a}$); 2.33–2.38 (t, $J$ = 7.35 Hz; 2H, $OCO\underline{CH_2}CH_2CH_2$); 2.40–2.52 (m, 1H, SCH-$\underline{H^b}$); 3.07–3.23 (m, 2H, $S\underline{CH_2}$); 3.41–3.50 (m, 4H, $O\underline{CH_2}(CH_2)_{12}CH_3$); 3.51–3.60 (m, 5H, $O\underline{CH_2}\underline{CH}\underline{CH_2}O$); 3.63–3.68 (m, 14H, TTEG $O\underline{CH_2}\underline{CH_2}O$); 3.69–3.70 (m, 1H, S$\underline{CH}$); 4.21–4.25 (m, 2H, $OCH_2\underline{CH_2}OCO$).

$^{13}$C NMR ($CDCl_3$, δ ppm): 14.11 ($\underline{C}H_3$), 22.68 ($\underline{C}H_2CH_3$), 24.61 ($COCH_2\underline{C}H_2$), 26.08 ($CHCH_2OCH_2CH_2\underline{C}H_2$), 26.13 ($CHOCH_2CH_2\underline{C}H_2$), 28.72 ($OCOCH_2CH_2\underline{C}H_2$), 29.35–29.69 (alkyl $\underline{C}H_2$), 30.10 ($CHCH_2OCH_2\underline{C}H_2$), 31.91 ($\underline{C}H_2CH_2CH_3$), 33.92 ($OCO\underline{C}H_2CH_2CH_2$), 34.58 ($OCOCH_2CH_2CH_2\underline{C}H_2$), 38.47 ($S\underline{C}H_2$), 40.20 ($SCH\underline{C}H_2$), 56.32 (S$\underline{C}$H), 63.44 ($OCH_2\underline{C}H_2OCO$), 69.16 ($O\underline{C}H_2CH_2OCO$), 70.55–71.66 (TTEG $O\underline{C}H_2\underline{C}H_2O$ and $O\underline{C}H_2CH\underline{C}H_2O$), 77.86 ($OCH_2\underline{C}HCH_2O$), 173.42 (C=O).

IR (KBr, υ cm$^{-1}$): 2923, 2854, 1738 (C=O), 1710, 1629, 1542, 1464, 1377, 1348, 1299, 1247, 1121, 950.

Found, %: C, 66.56; H, 10.98; O, 14.95; S, 7.35. Anal. calcd. for $C_{47}H_{92}O_8S_2$ (849.36), %: C, 66.46; H, 10.92; O, 15.07; S 7.55.

**14-(tetradecyloxy)-3,6,9,12,16-pentaoxatriacontyl methanesulfonate (5)**

Compound **5** was prepared by the same way as compound **2** from compound **3** (6 g, 9.08 mmol), TEA (2.53 mL, 1.83 g, 18.16 mmol), TMA·HCl (0.17 g, 18.16 mmol), MsCl (1.4 mL, 2.08 g, 18.16 mmol) in DCM (100 mL). Yied 6.6 g (98%).

$^1$H NMR ($CDCl_3$, δ ppm): 0.86–0.90 (m, 6H, $\underline{CH_3}$); 1.25–1.33 (br. s, 44H, $OCH_2CH_2(\underline{CH_2})_{11}CH_3$); 1.53–1.58 (m, 4H, $OCH_2\underline{CH_2}(CH_2)_{11}CH_3$); 3.08 (s, 3H, $OSO_2\underline{CH_3}$); 3.41–3.52 (m, 4H, $O\underline{CH_2}(CH_2)_{12}CH_3$); 3.53–3.58 (m, 5H, $\underline{CH_2}\underline{CH}\underline{CH_2}$); 3.63–3.68 (m, 12H, TTEG $O\underline{CH_2}\underline{CH_2}O$); 3.75–3.78 (m, 2H, $O\underline{CH_2}CH_2OSO_2CH_3$); 4.37–4.40 (m, 2H, $OCH_2\underline{CH_2}OSO_2CH_3$); 7.19 (s, 1H, $\underline{OH}$).

$^{13}$C NMR ($CDCl_3$, δ ppm): 14.11 ($\underline{C}H_3$), 22.68 ($\underline{C}H_2CH_3$), 26.08 ($CHCH_2OCH_2CH_2\underline{C}H_2$), 26.13 ($CHOCH_2CH_2\underline{C}H_2$), 29.35–30.10 (alkyl $\underline{C}H_2$), 31.91 ($\underline{C}H_2CH_2CH_3$), 37.71 ($OSO_2\underline{C}H_3$), 69.02 ($\underline{C}H_2OSO_2CH_3$), 69.23 ($CHO\underline{C}H_2CH_2$), 70.54–71.41 (TTEG $O\underline{C}H_2\underline{C}H_2O$ and $\underline{C}H_2CH\underline{C}H_2$), 71.66 ($CHCH_2O\underline{C}H_2CH_2$), 77.86 ($\underline{C}H$).

IR (KBr, υ cm$^{-1}$): 2955, 2918, 2850, 1467, 1349, 1174, 1113 (C-O), 921.

Found, %: C, 65.56; H, 11.08; O, 18.99; S, 4.25. Anal. calcd. for $C_{40}H_{82}O_9S$ (739.13), %: C, 65.00; H, 11.18; O, 19.48; S 4.34.

**2-(14-(tetradecyloxy)-3,6,9,12,16-pentaoxatriacontyl)isothiouronium methanesulfinate (6)**

Compound **5** (2 g, 2.71 mmol) and thiourea (0.309 g, 4.06 mmol) were dissolved in absolute 2-propanol (30 mL). The mixture was refluxed for 15 hours. Then reaction mixture was allowed to cool in a freezer during one night. Next, it was filtered and evaporated. The product was chromatographed on the silica gel column using benzene and acetone (5:1; 2:1; 1:1) solvents as an eluent. Yield 1.3 g (59%).

$^1$H NMR ($CDCl_3$, δ ppm): 0.86–0.90 (m, 6H, $\underline{CH_3}$); 1.25–1.33 (br. s, 44H, $OCH_2CH_2(\underline{CH_2})_{11}CH_3$); 1.50–1.57 (m, 4H, $OCH_2\underline{CH_2}(CH_2)_{11}CH_3$); 2.80 (s, 3H, $OSO_2\underline{CH_3}$); 3.22–3.25 (t, $J$ = 4.76; 2H, $OCH_2\underline{CH_2}S$); 3.40–3.49 (m, 4H, $O\underline{CH_2}(CH_2)_{12}CH_3$); 3.52–3.58 (m, 5H, $\underline{CH_2}\underline{CH}\underline{CH_2}$); 3.63–3.73 (m, 12H, TTEG $O\underline{CH_2}\underline{CH_2}O$); 3.85–3.89 (t, $J$ = 4.49; 2H, $O\underline{CH_2}CH_2S$); 8.48 (s, 2H, $\underline{NH_2}$); 9.27 (s, 2H, $\underline{NH_2}OSO_2CH_3$).

$^{13}$C NMR ($CDCl_3$, δ ppm): 14.11 ($\underline{C}H_3$), 22.68 ($\underline{C}H_2CH_3$), 26.06 ($CHCH_2OCH_2CH_2\underline{C}H_2$), 26.11 ($CHOCH_2CH_2\underline{C}H_2$), 29.35 ($\underline{C}H_2CH_2CH_2CH_3$), 29.51–30.03 (alkyl $\underline{C}H_2$), 31.91 ($\underline{C}H_2CH_2CH_3$), 39.46 ($OSO_2\underline{C}H_3$), 69.89–71.69 (TTEG $O\underline{C}H_2\underline{C}H_2O$ and $\underline{C}H_2CH\underline{C}H_2$), 77.71 ($\underline{C}H$), 171.57 ($\underline{C}(NH_2)_2$).

IR (KBr, υ cm$^{-1}$): 3306 (NH), 2955, 2917, 2849, 1731, 1664 (C=N), 1557, 1538, 1468, 1191, 1115 (C-O), 1043.

Found, %: C, 60.06; H, 11.00; N, 3.22; O, 18.02; S, 7.25. Anal. calcd. for $C_{41}H_{86}N_2O_9S_2$ (815.26), %: C, 60.40; H, 10.63; N, 3.44; O, 17.66; S 7.87.

**14-(tetradecyloxy)-3,6,9,12,16-pentaoxatriacontane-1-thiol (7)**

Compound **6** (1.2 g, 1.501 mmol) was dissolved in chloroform (25 mL) and water (15 mL) mixture. The sodium metabisulfite (0.571 g, 3 mmol) was added and the reaction mixture was refluxed under nitrogen for 4 hours. Then it was allowed to cool to room temperature and washed with water. The combined chloroform extracts were dried ($Na_2SO_4$), filtered and evaporated, yielding 0.8 g (79%) of corresponding compound **7**.

$^1$H NMR ($CDCl_3$, δ ppm): 0.86–0.90 (m, 6H, $\underline{CH_3}$); 1.25–1.33 (br. s, 44H, $OCH_2CH_2(\underline{CH_2})_{11}CH_3$); 1.51–1.61 (m, 5H, $OCH_2\underline{CH_2}(CH_2)_{11}CH_3$ and SH); 2.67–2.73 (q, $J$ = 6.76; 2H, $\underline{CH_2}SH$); 3.41–3.51 (m, 4H, $O\underline{CH_2}(CH_2)_{12}CH_3$); 3.52–3.60 (m, 5H, $\underline{CH_2}\underline{CH}\underline{CH_2}$); 3.62–3.67 (m, 14H, TTEG $O\underline{CH_2}\underline{CH_2}O$).

$^{13}$C NMR ($CDCl_3$, δ ppm): 14.13 ($\underline{C}H_3$), 22.68 ($\underline{C}H_2CH_3$), 24.72 ($\underline{C}H_2SH$), 26.08 ($CHCH_2OCH_2CH_2\underline{C}H_2$), 26.13 ($CHOCH_2CH_2\underline{C}H_2$), 29.37 ($\underline{C}H_2CH_2CH_2CH_3$), 29.51–30.10 (alkyl $\underline{C}H_2$), 31.91 ($\underline{C}H_2CH_2CH_3$), 70.32–72.89 (TTEG $O\underline{C}H_2\underline{C}H_2O$ and $\underline{C}H_2CH\underline{C}H_2$), 77.84 ($\underline{C}H$).

IR (KBr, υ cm$^{-1}$): 2923, 2853, 1720, 1466, 1393, 1350, 1298, 1250, 1114 (C-O), 1041, 944.

Found, %: C, 69.06; H, 11.05; O, 14.82; S, 4.95. Anal. calcd. for $C_{39}H_{80}O_6S$ (677.11), %: C, 69.18; H, 11.91; O, 14.18; S 4.74.

## CONCLUSIONS

In conclusion, we have developed an efficient synthesis of two glycerol-based thiolipids containing neutral and flexible

tetraethylene glycol chain with thiol and cyclic disulfide anchors for attachment onto a gold support. Derivatives **4** and **7** were successfully synthesized from inexpensive commercial reagents in good yields without an additional purification by column chromatography. The final compounds were used in the tBLM attachments and further development of model membranes.

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## GLICEROLIO TIOLIPIDŲ, SKIRTŲ MODELINĖMS MEMBRANOMS, SINTEZĖ

*S a n t r a u k a*

Iš pigių komercinių reagentų pasiūlytas efektyvus glicerolio tiolipidų, turinčių neutralią tetraetilenglikolio grandinę su tiolio bei ciklinio disulfido „inkarais", skirtų prijungimui prie aukso paviršiaus, sintezės būdas. Susintetinti galutiniai thiolipidai sėkmingai išskirti be papildomos kolonėlinės chromatografijos, jų struktūra patvirtinta spektroskopiniais metodais. Abu galutiniai junginiai buvo panaudoti kuriant prijungtas dvisluoksnes membranas bei toliau tiriant modelines membranas.