Electronic Supplementary Material (ESI) for Polymer Chemistry.

ESI for the paper

Entropically-driven Ring-opening Metathesis Polymerization (ED-ROMP) of Macrocyclic Olefins Prepared from Deoxycholic Acid to give Functionalized Polymers

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This ESI describes the syntheses of macrocycles discussed in the paper. The compound/formulae numbers remain the same, as do the reference numbers.

In the case of macrocycles **1** and **9** the syntheses involved three steps. (i) The appropriate bile acid was reacted with undec-10-enol in the presence of a catalytic amount of concentrated sulphuric acid;[7] (ii) the product from the first step was acylated by reaction with undec-10-enoyl chloride in the presence of pyridine;[7] (iii) the diester was then subjected to ring-closing metathesis using Grubbs First Generation catalyst.[7]

The syntheses of macrocycles **10** and **11** involved first preparing the methyl and *t*-butyl esters of deoxycholic acid (**12**).[18] The esters were then (i) acylated by reaction with undec-10-enoyl chloride in the presence of pyridine;[7] and (ii) the triesters obtained were subjected to ring-closing metathesis using Grubbs First Generation catalyst.[7]

Experimental Details

The materials and instruments were as indicated in the paper and reference 5.

1. Synthesis of Macrocycle 1

This macrocycle has been prepared before by Gautrot and Zhu.[7] The procedure was repeated without problem. Column chromatography of the crude reaction product gave cyclic monomer **1** (*E*- and *Z*-isomers) as white crystals (80%); m.p. 123 – 128 °C (lit.,[7] 119.6 °C by DSC); FT-IR (KBr) ν_{max} 1733 cm^{-1} (C=O); ^{1}H NMR (500 MHz, CDCl$_3$, δ, ppm) 5.38 (m, 2 H, CH=), 4.72 (m, 1 H, 3β-CH), 4.08 (m, 2 H, CH$_2$OCO), 2.40 – 2.11 (m, 4 H, 23CH$_2$ and CH$_2$CO), 2.0 – 0.9 (m, 56 H, various CH), 0.92 (s, 3 H, C19), 0.90 (d, J = 10 Hz, 3 H, C21 methyl), 0.64 (s, 3 H, C18); MS MALDI ToF 690, $C_{44}H_{74}O_4Na^+$ requires 689.6. Another column fraction was, by MALDI ToF, mainly C1 (690) with much smaller amounts of C2 (1357) and (C3) 2028.

2. Synthesis of Macrocycles 9

Undecenyl deoxycholate was prepared by reacting deoxycholic acid with an excess of undec-10-enyl alcohol in the presence of a catalytic amount of concentrated sulphuric acid. This gave the desired product as a clear gum (88%) with FT-IR (KBr) ν_{max} 3610 br (OH), 1736 cm^{-1} (C=O); ^{1}H NMR (400 MHz, CDCl$_3$, δ, ppm) 5.81 (m, 1 H, CH=), 4.94 (m, 2 H, =CH$_2$), 4.03 (m, 2 H, CH$_2$OCO), 3.98 (m, 1 H, 12β-H), 3.61 (m, 1 H, 3β-H), 2.38 (m, 1 H, 23-H), 2.23 (m, 1 H, 23-H), 2.00 (m, 2 H, CH$_2$CO$_2$), 1.9 – 1.0 (m, 40 H, various CH), 0.97 (d, J = 8 Hz, 3H, C21 methyl), 0.91 (s, 3H, C19), 0.67 (s, 3H, C18). Calculated for $C_{35}H_{60}O_4$: C, 77.15; H, 11.10 %. Found: C, 76.93; H, 10.92 %.

Undecenyl undecanoydeoxycholate was prepared by reacting the above ester with undec-10-enoyl chloride in the presence of pyridine.[22] It was obtained as white crystals (89%); mp 58 – 60 °C; FT-IR (KBr) ν_{max} 1730 cm^{-1} (C=O); ^{1}H NMR (300

MHz, $CDCl_3$, δ, ppm) 5.80 (m, 2 H, CH=), 4.97 (m, 4 H, $=CH_2$), 4.71 (m, 1 H, 3β-H), 4.05 (m, 2 H, CH_2OCO), 4.01 (m, 1 H, 12β-H), 2.30 (m, 1 H, 23-H), 2.23 (m, 3 H, 23-H and CH_2CO_2), 2.03 (m, 2 H, CH_2CO_2), 1.9 – 1.0 (m, 53 H, various CH), 0.97 (d, J = 8 Hz, 3H, C21 methyl), 0.91 (s, 3H, C19), 0.67 (s, 3H, C18). $C_{46}H_{78}O_5$ requires C, 77.69; H, 11.06 %. Found: C, 77.39; H, 10.88 %.

MCOs ***9*** were prepared by ring-closing metathesis using the general procedure described by Gautrot and Zhu.[7] Column chromatography of the crude product gave MCOs **9** as a pale fawn glass (78 %); FT-IR (KBr) ν_{max} 3100 br. (OH), 1731 cm^{-1} (C=O); ^1H NMR (400 MHz, $CDCl_3$, δ, ppm) 5.33 (m, 2 H, CH=, *E*- and *Z*-isomers), 4.70 (m, 1 H, 3β-CH), 4.00 (m, 2 H, CH_2OCO), 3.90 (m, 1 H, 12β-H), 2.35 – 2.10 (m, 4 H, $^{23}CH_2$ and CH_2CO), 2.0 – 1.0 (m, 55 H, various CH), 0.92 (d, J = 10 Hz, 3 H, C21 methyl), 0.90 (s, 3 H, C19), 0.64 (s, 3 H, C18); MS MALDI ToF 707, $C_{44}H_{74}O_5Na^+$ requires 706.0. Also peaks due to C2 (1390) and C3 (2072). SEC: C1, 85%, C2, 13%, and C3, 2%. $C_{44}H_{74}O_5$ requires C, 77.37; H, 10.92 %. Found: C, 77.09; H, 10.68 %.

3. Synthesis of Macrocycles 10

Methyl deoxychlolate was prepared as described by Gangwal *et al.*[18a] It had m.p. 112 - 118 °C (lit.,[18a] 120 °C).

Methyl Diundecanolyldeoxycholate. This compound was obtained in the form of a foam (102%) with FT-IR (KBr) ν_{max} 1739 cm^{-1} (C=O); ^1H NMR (300 MHz, $CDCl_3$, δ, ppm) 5.81 (m, 2 H, CH=), 5.05 (m, 1 H, 12β-H), 4.97 (m, 4 H, $=CH_2$), 4.71 (m, 1 H, 3β-H), 2.3 – 2.0 (m, 6 H, CH_2CO_2), 1.9 – 1.0 (m, 26 H, various CH), 1.42 (s, 9 H, t-butyl), 0.92 (s, 3H, C19), 0.85 (d, J = 8 Hz, 3H, C21 methyl), 0.71 (s, 3H, C18).

Macrocycles ***10***. Ring-closing metathesis of the preceding ester gave, after chromatography, the desired MCOs **10** as a colourless gum (67 %); FT-IR (ATR) ν_{max} 1728 cm^{-1} (ester carbonyl); ^{1}H NMR (500 MHz, CDCl$_3$, δ, ppm) 5.38 (m, 2 H, CH=, *E*- and *Z*-isomers), 5.13 (m, 1 H, 12β-CH), 4.74 (m, 1 H, 3β-CH), 3.70 (s, 3 H, OCH$_3$), 2.45 – 2.15 (m, 6 H, CH$_2$CO), 2.1 – 1.0 (m, 52 H, various CH), 0.93 (s, 3 H, C19), 0.84 (d, *J* = 10 Hz, 3 H, C21 methyl), 0.76 (s, 3 H, C18); MS MALDI ToF 734 and 750, $C_{45}H_{74}O_6Na^+$ requires 734.1, $C_{45}H_{74}O_6K^+$ requires 750.2. SEC: C1, 79% and C2, 21%. $C_{45}H_{74}O_6$ requires C, 76.01; H, 10.49 %. Found: C, 76.22; H, 10.60 %

4. Synthesis of Macrocycles 11.

t-Butyl deoxycholate:- This compound was prepared as described by Alexander *et al.*[18b] It was obtained as white crystals with m.p. 74-77 °C (from water/ethanol) (lit.,[18b] 72 - 76 °C); FT-IR (KBr) ν_{max} 3390 br. (OH), 1730 cm^{-1} (C=O).

t-Butyl Diundecanolyldeoxycholate. The above ester was reacted with undec-10-enoyl and pyridine using the standard procedure. It was obtained in the form of a foam (102%) with FT-IR (KBr) ν_{max} 1739 cm^{-1} (C=O); ^{1}H NMR (300 MHz, CDCl$_3$, δ, ppm) 5.81 (m, 2 H, CH=), 5.05 (m, 1 H, 12β-H), 4.97 (m, 4 H, =CH$_2$), 4.71 (m, 1 H, 3β-H), 2.3 – 2.0 (m, 6 H, CH$_2$CO$_2$), 1.9 – 1.0 (m, 26 H, various CH), 1.42 (s, 9 H, *t*-butyl), 0.92 (s, 3H, C19), 0.85 (d, *J* = 8 Hz, 3H, C21 methyl), 0.71 (s, 3H, C18). $C_{50}H_{84}O_6$ requires C, 76.87; H, 10.84 %. Found: C, 76.80; H, 10.67 %.

MCOs ***11***. These MCOs were prepared by ring-closing methathesis using the standard procedure.[7] Ring-closing metathesis was carried out using the general procedure. By ^{1}H NMR spectroscopy, based on signals in the vinyl region, the crude product was estimated to contain about 8% of starting material and/or linear oligomers. Starting with this product the entire RCM procedure was, therefore, repeated. Column chromatography of the crude product gave the desired product as a clear oil (85 %); FT-IR (ATR) ν_{max} 1738 cm^{-1} (ester carbonyl); ^{1}H NMR (500 MHz, CDCl$_3$, δ, ppm) 5.34 (m, 2 H, CH=, *E*- and *Z*-isomers), 5.08 (m, 1 H, 12β-CH), 4.71 (m, 1 H, 3β-CH), 2.40 – 2.30 (m, 6 H, CH$_2$CO), 2.1 – 1.0 (m, 52 H, various CH), 1.44 (s, 9 H, *t*-butyl), 0.91 (s, 3 H, C19), 0.80 (d, *J* = 10 Hz, 3 H, C21 methyl), 0.72 (s, 3 H, C18). SEC: C1, 60% and C2, 40%. $C_{48}H_{80}O_6$ requires C, 76.54; H, 10.71 %. Found: C, 76.22; H, 10.60 %.

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