Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2018, 10(11): 48-62

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Design and Synthesis of New Types of Macro Cycles Containing Tetralactone Functionalities

Giriraj S.Mandloi[1], Smita Joshi[2], Alka Mishra[3] and Sulbha Amlathe[1*]

[1]*Department Applied Chemistry, UIT, Barkatullah University, Bhopal – 462064, MP, India*
[2]*Chemistry Department, SNGPG College, Bhopal – 462064, MP, India*
[3]*CSIR-Advanced Materials and Processes Research Institute (AMPRI) Bhopal -462026, MP, India*

ABSTRACT

The synthesis of the novel macrocycle rings derived from bola-shaped diester–dicarboxylic acid in addition to syntheses of macro cyclic tetra lactones with various diacids and ditosylated diols ring compounds. The structures of these compounds are established by electro spray ionization mass spectrometry (ESI-MS), Fourier transform infrared spectroscopy (FT-IR), FE-SEM, NMR spectroscopic methods and thermal decomposition experiments using Mettler Toledo TGA/DSC1, STARe under a nitrogen atmosphere. The heating rate of the thermal decomposition employed was 10°C min-1, wherever applicable.

Keywords: Bola-shaped; Diacids; Ditosylated diols; Macro cyclic tetra lactones

---

INTRODUCTION

A macrocycle is defined as a cyclic macromolecular cyclic portion of a molecule [1-5]. In the chemical literature, macrocycles varyingly include molecules containing rings of 8 or more atoms. In general, coordination chemists define a macrocycle more narrowly as a cyclic molecule with three or more potential donor atoms that can coordinate to a metal centre [6]. A well-known example is the group of drugs known as macrolides. The IUPAC definition notes that a "cyclic macromolecule has no end-groups but may nevertheless be regarded as a chain," and that "macrocycle is sometimes used in the literature for molecules of low relative molecular mass that are not considered 'macromolecules [7-9]. This property of coordinating macrocyclic molecules is termed the macrocycle effect, and is a special example of the chelate effect. This so-called macrocyclic effect is thought to be a combination of the entropic effect seen in the chelate effect, together with an additional energetic contribution that comes from the reorganized nature of the ligating groups [10,11]. Macrocycles have been in use for several decades as synthetic dyes. For the purposes of this study, a macrocycle is defined as a cyclic compound with nine or more members including at least three donor atoms. Starting with simple and existing lactones, the chemistry of more elaborated carbohydrate-based lactones, such as α, β-unsaturated δ-lactones as well as other types of bicyclic systems will then be presented and discussed [12-15]. Among many polymers, polyethylene glycol is one of the most widely used materials in various fields such as drug delivery, gene delivery, lithium polymer electricity storage

systems, plastics industry and so on [16]. Polyethylene glycol is a very important biocompatible polymer that facilitates solubilisation and long-term circulation of proteins, viruses and other biological macromolecules [17-19]. It can provide charge-neutral synthetic coatings on nanoparticles that dictate its solubility and interactions with macromolecules and cell surfaces. Similar to various ring compounds, metallomacrocycles deserve significant importance because of their potential applications in varieties of interdisciplinary research. Macrocycles, possessing a cyclic ring and a metal active site, are important [20-22]. In the present study, we report the synthesis of the novel macrocycle rings derived from bola-shaped diester–dicarboxylic acid in addition to syntheses of macro cyclic tetra lactones with various diacids and ditosylated diols ring compounds. The structures of these compounds are established by electro spray ionization mass spectrometry (ESI-MS), Fourier transform infrared spectroscopy (FT-IR), and NMR spectroscopic methods, wherever applicable.

MATERIALS

All chemicals were used as received from the manufacturer without further purification. P-toluenesulfonyl chloride (PTSC), Diethylene glycol (DEG), Tetra ethylene glycol (TEG), tetrahydrofuran (THF) sodium hydrogen carbonate (SHC), Acetonitrile (ACN), Potassium carbonate (K_2CO_3) and hydrochloric acid (HCL) were purchased from Sigma-Aldrich or EMD. Microanalysis of the compounds was done using an Elemental HITACHI CHNS/O analyzer, Germany at CSIR, AMPRI, Bhopal. Mass analysis was performed using electron spray ionization (ESI^+) technique on water QT of-micro mass spectrometer. FT-IR spectra were recorded using KBr pellets on a Perkin-Elmer Spectrum DRS, FT-IR spectrometer. 1H and 13C NMR spectra were recorded (200 and 50.3 MHz, respectively) on a BRUKER Advance DPX 200 NMR spectrometer using methanol-d4 or $CDCl_3$. 900 pulses for 1H (8.9 µs) and 13C (5.9 µs) nucleus was determined using Bruker XWIN-NMR software using standard ‘‘paropt” pulse program at CSIR, CSMCRI, Bhavnagar, Gujarat and SAIF at Panjab University Chandigarh. All 1H NMR and 13C NMR spectra were calibrated with respect to TMS and TMS was used as an internal reference for solvents such as $CDCl_3$ and CD_3OD. Thermal decomposition experiments using Mettler Toledo TGA/DSC1, STARe under a nitrogen atmosphere. The heating rate of the thermal decomposition employed was 10°C min^{-1}.

METHODOLOGY

Syntheses

The synthesis of Tosylated diol (TD) compounds and macro cyclic tetra Lactones (MCTL) are depicted in Table 1 and Table 2, respectively. These compounds were synthesized and characterized by using various spectroscopic techniques such as NMR, FT-IR, MS, and TGA/DSC. All these diacids compounds were own as per syntheses in previous Chapeter-1, the compounds (1b, 1d, 1e and 1f) as spacer moiety shown in Figure 1. Phthalic anhydride is head group upon introducing spacer moiety 4-butyne diol (b) 1, 4-cyclohexane dimethanol (d), ethane-1, 2-diol (e), and 2-Butyene-1, 4-diol (f) to alter the length between the head groups of the bola-shaped compounds.

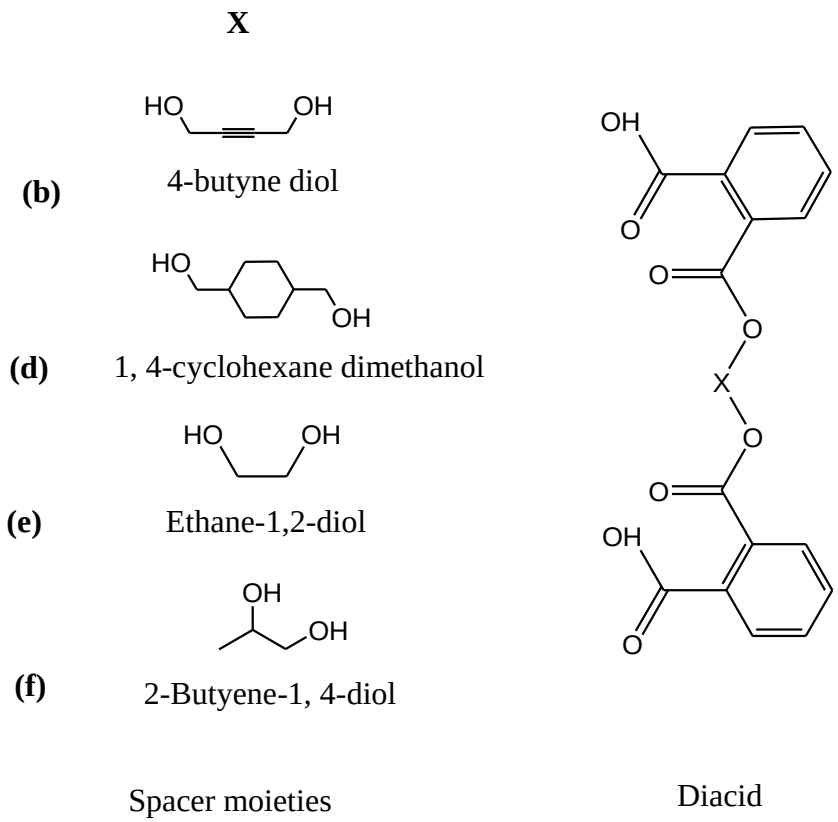


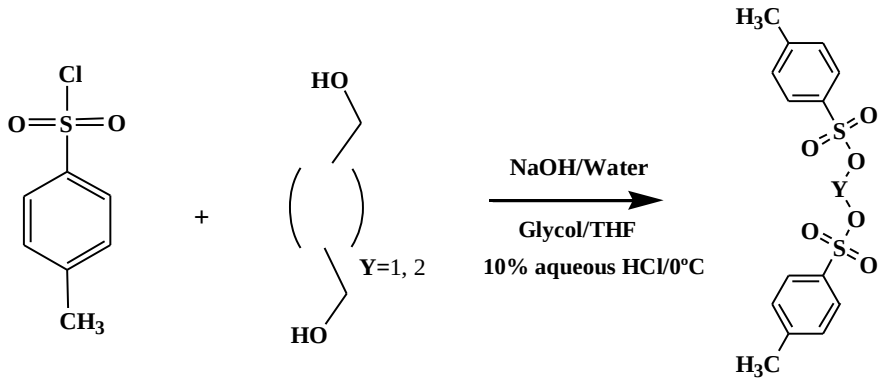
Figure 1. Dihydroxy diacids compounds used as spacer moiety

General Procedure for the Synthesis of Tosylated Diol Synthesis, Method-A

Sodium hydroxide (12.0 g, 0.33 mol) dissolved in water (100 mL) and glycols (0.15 mol) in THF (100 mL) were mixed in the flask. To the stirred mixture at 0ºC was added p-toluenesulfonyl chloride (62.9 g, 0.33mol) in THF (150ml) drop wise over 2 h, and stirring was continued for an addition 2 h. at that temperature. The mixture was then poured into 10% aqueous hydrochloric acid at 0ºC. The precipitate dissolute was filtered, washed with water and aqueous dilute sodium hydrogen carbonate, and then dried in a vacuum. Recrystallization from Methanol gave the ditosylate in 79-89% yield.

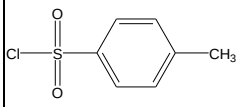
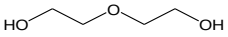
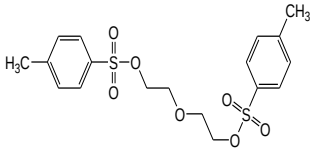
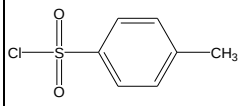
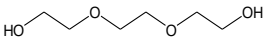
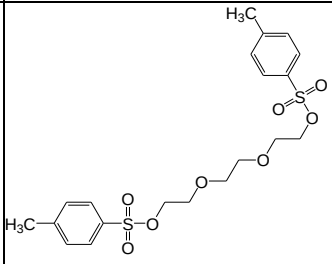
Synthesis of Tosylated Diol

Mechanism



P-toluenesulfonyl chloride Glycols Ditosylated Diol

Table 1. Syntheses of Ditosylated diols with P-toluenesulfonyl chloride and various glycols

Sr. No.	P-toluenesulfonyl chloride	Glycols	Ditosylated diols	Yield %
1				**79**
2				**89**

Yields are unoptimized and refer to isolated pure compounds.

Synthesis and characteristics of Ditosylated diols formed with *P-toluenesulfonyl chloride* and different *Glycols* are as under: Compound No.1: i.e. 4-Methyl-benzenesulfonic acid 2-[2-toluene-4-sulfonylloxy) -ethoxy] -ethyl ester (TS-1).

Take Diethylene Glycol (4.732 ml, 0.05 mol) and add tosylchloride (19.06 g, 0.1 mol) and sodium hydroxide (4 g, 0.1mol) were allowed to react in dry ACN according method A to afford the Diethylene Glycol Ditosylate 1 (Yield, 79%) as White crystalline precipitate. ^{1}H NMR δ ($CDCl_3$, 400.13MHz): 7.33-7.78 (m, 8H, Ar-H), 4.17-4.15 (t, 2 H, O_2SOCH_2), 4.07-4.09 (t, 4H, -CH_2),3.58-3.61 (t, 4H, -CH_2), 2.44 (s, -CH_3); ^{13}C NMR δ ($CDCl_3$, 125.76MHz): 144.49 (quat -C), 138.2 (quat-C), 128.77 (quat -C), 129.33 (quat -C), 129.70 (=CH), 130.94 (=CH), 131.37 (=CH), 131.82 (=CH), 65.56 (-CH_2), 24.91 (-CH_3). IR spectral data: (V_{max}/cm^{-1}), 3973, 3924, 3776, 3729, 2869, 2591, 2520, 2413, 2273, 2201, 19125, 1597, 1216, 1023, 947, 829, 675, 578. HRMS (ESI^+): Calcd. for $C_{18}H_{22}O_7S_2Na$ ($M+Na^+$): 414, Found 414.1.

Compound No.2: i.e,. 4-Methyl-benzenesulfonic acid 2-{2-[2-toluene-4- sulfonylloxy)-ethoxy]-ethoxy}-ethyl ester (TS-2).

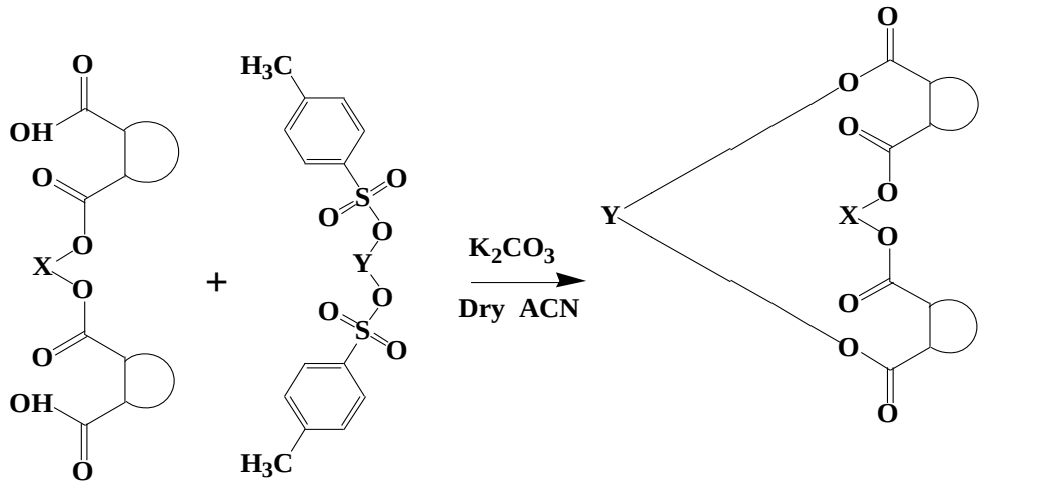
Take Triethylene Glycol (6.60 ml, 0.05mol) and add tosylchloride (21.0 g, 0.1 mol) and sodium hydroxide (4 g, 0.1 mol) were allowed to react in dry ACN according method A to afford the Diethylene Glycol Ditosylate 2 (Yield, 89%) as White crystalline precipitate. ^{1}H NMR δ ($CDCl_3$, 400.13 MHz): 7.73-7.79 (m, 8H, Ar-H), 4.26-4.26 (t, 2 H, O_2SOCH_2), 4.12-4.19 (t, 4H,-CH_2), 3.52-3.69 (t, 4H, -CH_2), 2.44 (s, -CH_3) ; ^{13}C NMR δ ($CDCl_3$, 125.76MHz): 144.49 (quat -C), 138.2 (quat -C), 128.77 (quat -C), 129.33 (quat -C), 129.70 (=CH), 130.94 (=CH), 131.37 (=CH), 131.82 (=CH), 70.50 (-CH_2), 65.56 (-CH_2), 24.91 (-CH_3). IR spectral data: (V_{max} /cm^{-1}), 3973, 3880, 3803, 3729, 3673, 2871, 2743, 2690, 2594, 2518, 2404, 2269, 2115, 1935, 1824, 1726, 1180, 1017,913, 813, 695, 664, 578. HRMS (ESI^+): calcd. for $C_{20}H_{26}O_8S_2Na$ ($M+Na^+$): 458, Found 458.1.

General Procedure for the Synthesis of Macro Cyclic Tetra Lactones, Method-B

To an oven-dried flask dicarboxylic acids (2.5 mol) in dry ACN (150 mL) were charged under inert atmosphere. To the above solution, tosylated diols (2.5 mmol) was added and the reaction mixtures were stirred and after dissolving the compound add K_2CO_3. The Reaction mixture was stirred at 80-85ºC for 24 hrs. The Progress of the reaction was monitored using Thin Layer Chromatography (TLC). Finally, the white solid obtained in the reaction was evaporated. The residue was extracted with $CHCl_3$ and water mixture. The resultant $CHCl_3$ layer was collected and evaporated. The residue obtained was kept at 0ºC for overnight. The analysis was used to confirm the formation of compounds.

Synthesis of Macro Cyclic Tetralactone

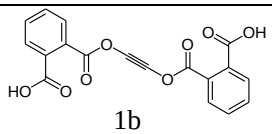
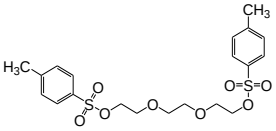
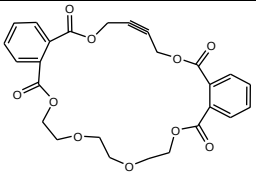
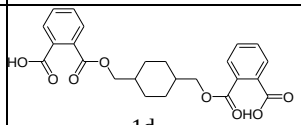
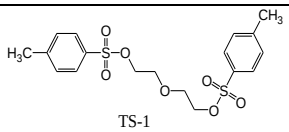
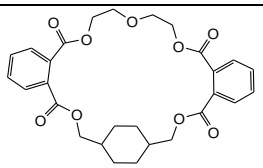
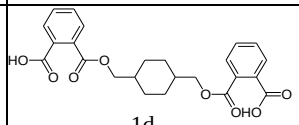
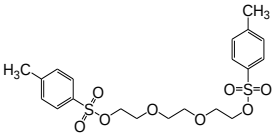
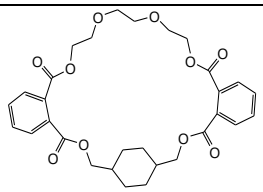
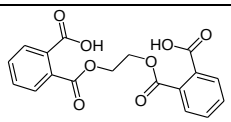
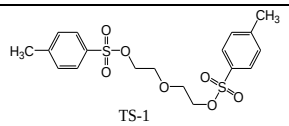
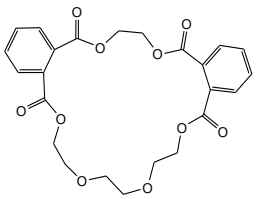
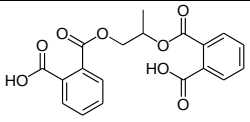
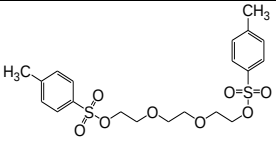
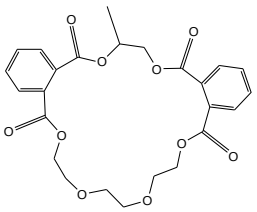
Mechanism



Diacid Ditosylated Diol Macrocyclic tetralactone

Table 2. Syntheses of Macro cyclic tetra lactones with various diacids and Ditosylated diols

S. No.	Bolaamphiphile diacids	Ditosylated diols	Macro cyclic tetra lactones	Yield %

1	 1b	 TS-2	 M-1	**85**
2	 1d	 TS-1	 M-2	**90**
3	 1d	 TS-2	 M-3	**85**
4	 1e	 TS-1	 M-4	**80**
5	 1f	 TS-2	 M-5	**87**

Synthesis and characteristics of Macro cyclic tetra lactones formed with *Bolaamphiphile diacids* and different *Ditosylated diols* are as under: Macro cycle compound No. M-1: Bolaamphiphile diacid 1b (0.764 g, 0.002 mol), Triethylene Glycol Ditosylate (0.91g, 0.002 mol) and K_2CO_3 (0.552 g, 0.004 mol), were allowed to react in dry ACN according to the method-B to afford the macro cyclic tetra lactone M-1 (Yield, 85%). ^{1}H NMR d ($CDCl_3$, 500.13MHz): 7.27-7.84 (m, 8CH, Ar-H), 1.89-1.90 (t, 4H, -CH_2),), 4.35-4.37 (t, 4H, -CH_2); ^{13}C NMR d. ($CDCl_3$, 125.76MHz): 173.79 (C=O), 167.09 (C=O), 132.19 (quat -C), 131.82 (quat -C), 131.86 (=CH), 131.44 (=CH),

130.82 (=CH), 129.36 (=CH), 80.22 (-C=C-), 53.12 ($-CH_2$). IR spectral data: (V_{max} /cm^{-1}), 3447, 2991, 2856, 2683, 2559, 2113, 1755, 1731, 1696, 1598, 1580, 1494, 1428, 1372, 1315, 1285, 1152, 951, 764. HRMS(ESI^+): calcd. for $C_{26}H_{24}O_{10}Na$ (M+ Na^+): 519, Found 519.17.

Macro cycle compound No. M-2: Bolaamphiphile diacid 1 d (0.744 g, 0.002 mol), Diethylene Glycol Ditosylate (0.828 g, 0.002 mol) and K_2CO_3 (0.552g, 0.004 mol), were allowed to react in dry ACN according to the method-B to afford the macro cyclic tetralactone M-2 (Yield, 90%). ^{1}HNMR d ($CDCl_3$, 500.13 MHz): 7.54-7.87 (m, 8H, Ar-H), 4.22-4.24 (t, 4H,-CH_2), 1.21-1.86 (m, 10H, -CH_2) cyclohexane; ^{13}CNMR d. ($CDCl_3$, 125.76 MHz): 174.31 (C=O), 167.34 (C=O), 132.52 (quat -C), 132.14 (quat -C), 130.66 (=CH), 130.00 (=CH), 129.71 (=CH), 128.84 (=CH), 70.50 (-CH_2), 37.13 (-CH), 28.73 (-CH_2), 24.40 (-CH_2). IR spectral data: (Vmax /cm^{-1}), 3478, 3030, 2922, 2558, 2363, 1743, 1689, 1598, 1492, 1422, 1283, 1249, 1125. HRMS (ESI^+): calcd. for $C_{30}H_{34}O_{10}Na$ (M+ Na^+): 577, Found 577.52.

Macro cycle compound No. M-3: Bolaamphiphile diacid 1d (0.744 g, 0.002 mol), Triethylene Glycol Ditosylate (0.91g, 0.002 mol) and K_2CO_3 (0.552g, 0.004 mol), were allowed to react in dry ACN according to the method-B to afford the macro cyclic tetra lactone M-3 (Yield, 85%). ^{1}HNMR d ($CDCl_3$, 500.13MHz): 7.54-7.87 (m, 8H, Ar-H), 4.22-4.24 (t, 4H,-CH_2), 1.21-1.86 (m, 10H, -CH_2) cyclohexane; ^{13}CNMR d. ($CDCl_3$, 125.76 MHz): 174.31 (C=O), 167.34 (C=O), 132.52 (quat -C), 132.14 (quat -C), 130.66 (=CH), 130.00 (=CH), 129.71 (=CH), 128.84 (=CH), 70.50 (-CH_2), 37.13 (-CH), 28.73 (-CH_2), 24.40 (-CH_2). IR spectral data :(Vmax/cm^{-1}), 3478, 3030, 2922, 2558, 2363, 1743, 1689 1598, 1492, 1422, 1283, 1249, 1125. HRMS (ESI^+): calcd. for $C_{26}H_{24}O_{10}Na$ (M+ Na^+): 519, Found 519.17.

Macro cycle compound No. M-4: Dicarboxylic acid 1e (0.882g, 0.002 mol), Diethylene Glycol Ditosylate (0.828 g, 0.002 mol) and K_2CO_3 (0.550 g, 0.004 mol), were allowed to react in dry ACN according to the method-B to afford the macro cyclic tetra lactone M-4 (Yield, 80%). ^{1}H NMR δ (DMSO, 400.13MHz): 7.40-7.79 (m, 8H, Ar-H), 5.65 (t, 1H, -CH), 3.53-3.66 (m, 2H, -CH_2), 2.31-2.42 (d, 3H, -CH_3), ^{13}C NMR δ (CD_3OH, 50 MHz): 167.1 (C=O), 167.0 (C=O), 132.4 (quat –C), 129.8 (quat –C), 133.1 (=CH), 133.0 (=CH), 128.9 (=CH), 128.8 (=CH), 71.7-67.0 (–CH_2), 17.9 (-CH_3). IR spectral data: (V_{max} /cm^{-1}), 3426 (-OH), 3071 (Ar.-CH), 2966, 2877 (Aliphatic -CH), 2675, 2542, 2110, 1721 (C=O ester), 1694 (C=O acid), 1601, 1420, 1311, 1126 (C-O), 1017,913, 813, 695, 664, 578. HRMS (ESI^+) calcd. for $C_{28}H_{30}O_9Na$ (M+ Na^+): 533, Found 533.38.

Macro cycle compound No. M-5: Bolaamphiphile diacids 1f (0.744 g, 0.002 mol), Triethylene Glycol Ditosylate (0.91 g, 0.002 mol) and K_2CO_3 (0.552 g, 0.004 mol), were allowed to react in dry ACN according to the method-B to afford the macro cyclic tetralactone M-5 (Yield, 87%). ^{1}H NMR δ (DMSO, 400.13 MHz): 7.15-7.70 (m, 8H, Ar-H), 2.344 (d, 3H, -CH_3), 3.52-3.65 (m, 2H, -CH_2), 5.65 (t, 1H, -CH). ^{13}C NMR δ (CD_3OH, 50 MHz): 167.8 (C=O), 169.5 (C=O), 133.5 (quat –C), 167.6 (quat –C), 132.3 (=CH), 129.5 (=CH), 129.2 (=CH), 128.5 (=CH), 73.2-62.9 (–CH_2), 20.0-19.88 (-CH_3). IR spectral data: (V_{max} /cm^{-1}) 169.58 (C=O), 168.86 (C=O), 132.36, 132.01(quat-C), 131.37, 131.05, 129.04, 128.53 (=CH), 72.7 (–CH_2), 61.4 (–CH_2). HRMS (ESI^+) calcd. for $C_{25}H_{26}O_{10}$ (M+ Na^+): 509, Found 509.58.

RESULT AND DISCUSSION

The main objective was to develop a simple and cost proficient route to obtain a new type of macro cyclic tetra lactones (MCTL) functionalities compounds. The synthesis described here, depicted in high yield in above Table 1 and Table 2 respectively. Figure 1, bolaamphiphiles is based on modified diols spacer moiety reaction briefly noted in the introduction of marcrocyclic tetralactone compounds. Ditosylated diols were converted to glycols by reaction with p-toluenesulfonyl chloride (PTC). Since ditosylated diols have two terminals CH_3 groups, tosylation occur on both ends, but adding 1:1 mol of ditosylated diols and diacid to produced macrocyclic tetralactone produced 80-90% reported yields for these compounds.

NMR Investigation

^{1}HNMR and ^{13}CNMR spectra of compounds showed in Table 1 and Table 2, respectively, recorded in CD3OD and $CDCl_3$ (all data given in experimental section) and the corresponding spectra are presented in Figure 2a and 2b and Figure 3a and 3b of compound TS-1 and TS-2, and similarly in Figure 4a and 4b of Macrocyclic compounds M-5 respectively. The ^{1}H NMR signal correspond to the -O_2SOCH_2 and -CH_2, -CH_3 groups of the compound (TS-1-TS-2) and dissolved in CD3OD and $CDCl_3$ gives a broad signal at 7.33-7.78 (m, 8H, Ar-H), 4.17-4.15 (t, 2 H, O_2SOCH_2), 4.07-4.09 (t, 4H, -CH_2),3.58-3.61 (t, 4H, -CH_2), 2.44 (s, -CH_3 δ in (TS-1) and 7.73-7.79 (m, 8H, Ar-H), 4.26-4.26 (t, 2 H, -O_2SOCH_2), 4.12-4.19 (t, 4H,-CH_2), 3.52-3.69 (t, 4H, -CH_2), 2.44 (s, -CH_3) in (TS-2) merged with an aromatic region. Similarly the ^{1}H NMR signal correspond to aromatic 8-CH exhibits three to four signals at in compound (M-1-M-5) is 7.27-7.84, 7.54-7.87, 7.54-7.87, 7.40-7.79 , 7.15-7.70 (m, 8-CH, Ar-H), cyclohexane in 1.21-1.86, and 1.21-1.86 (m, 10H, -CH_2) compounds in (M-2 and M-3), respectively, and 4.35-4.37 (t, 4H, -CH_2), 4.22-4.24 (t, 4H,-CH_2), 4.22-4.24 (t, 4H,-CH_2), 3.53-3.66 (m, 2H, -CH_2), 3.52-3.65 (m, 2H, -CH_2) δ, and aliphatic CH_2 hydrogen's two distinct double signals for compound (M-1-M-5) in $CDCI_3$ and DMSO respectively. A similar observation based on the ^{13}C NMR data lead us to conclude the formation of tosylated diols 144.49 (quat -C), 138.2 (quat -C), 128.77 (quat -C), 129.33 (quat -C), 129.70 (=CH), 130.94 (=CH), 131.37 (=CH), 131.82 (=CH), 65.56 (-CH_2), 24.91 (-CH_3) in compound (TS-1), 144.49 (quat -C), 138.2 (quat -C), 128.77 (quat -C), 129.33 (quat -C), 129.70 (=CH), 130.94 (=CH), 131.37 (=CH), 131.82 (=CH), 70.50 (-CH_2), 65.56 (-CH_2), 24.91 (-CH_3) in compound (TS-2), and similarly, all the data of Macro cyclic tetra lactones are given in experimental section in (M-1-M-5) compounds in this work.

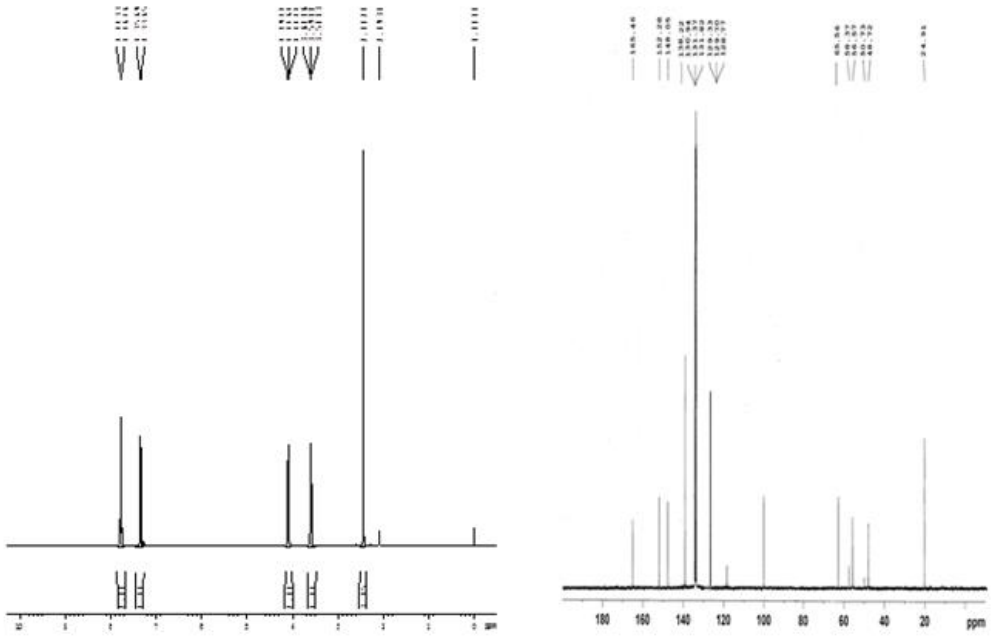


Figure 2. (a) ^{1}HNMR (400.13MHz) Spectra of compound (TS-1) in $CDCl_3$, (b) ^{13}CNMR (125.76MHz); (b) Spectra of compound (TS-1) in $CDCl_3$

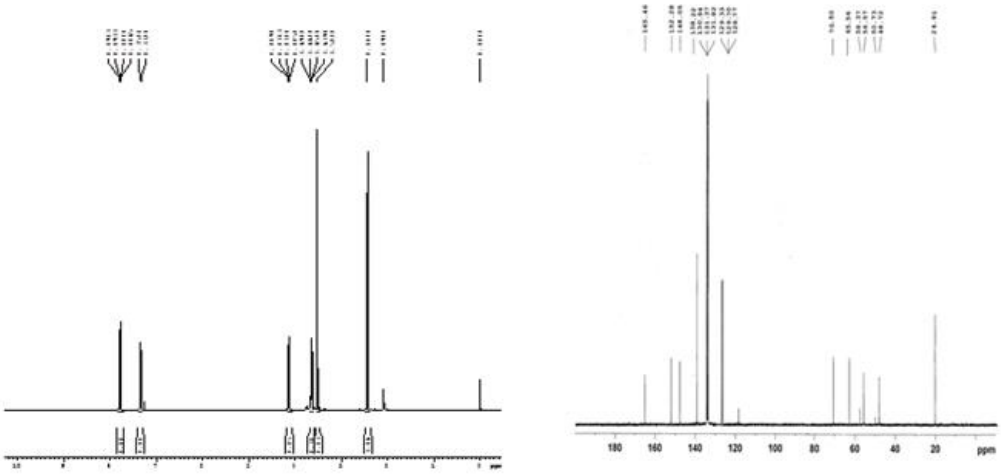


Figure 3. (a) ^{1}HNMR (400.13MHz) Spectra of compound (TS-2) in $CDCl_3$, (b) ^{13}CNMR (125.76MHz) Spectra of compound (TS-2) in $CDCl_3$

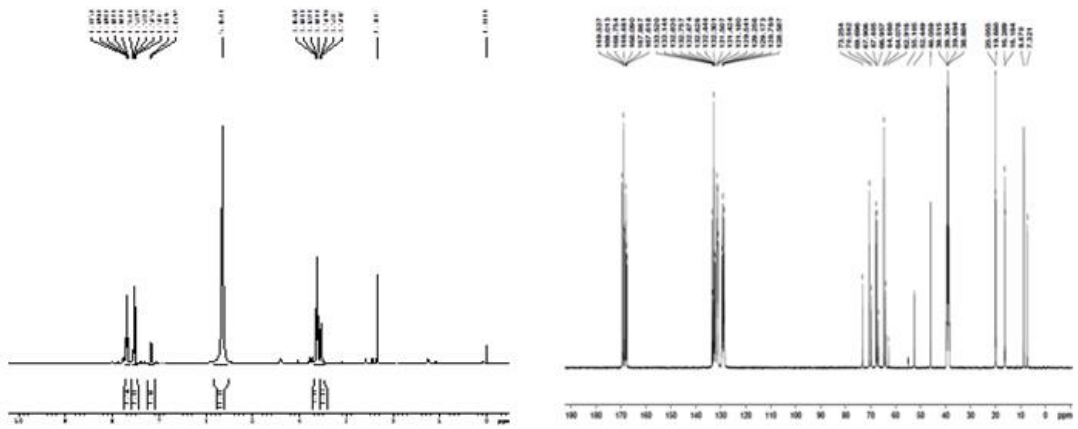


Figure 4. (a) ^{1}HNMR (400.13MHz) Spectra of compound (M-5) in DMSO, (b) ^{1}HNMR (50MHz) Spectra of compound (M-5) in CD_3OH

FT-IR Investigation

All ditosylated diols (TS-1 and TS-2) and macro cyclic tetra lactones compounds from (M-1 to M-5) possessing is known to provide lactone-based macrocyclic compounds. Though there are significant numbers of macrocycles available in with lactone (-C (=O)-O-) based rings is rare in the literature. With an aim to synthesize the macrocyclic compound possessing both lactone functional groups, we have adapted the reaction monitored using TLC at 0ºC for the overnight condition in the present synthesis. Accordingly, the bola-shaped diester dicarboxylic compound (L-1) was obtained by desymmetrizing phthalic anhydride using ethanediol. Mechanism-3.3 represents, the various synthetic strategies made to order for the arrangement of five different macrocyclic compounds, from (M-1 to M-5) using the TS-1 and TS-2, respectively. The response of an assortment of spacer ditosylated diols gave the macro cyclic compounds. In general, the syntheses of macrocycles compounds with lactones were performed by treating the diol and anhydride in the presence of 10% aqueous hydrochloric acid and K_2CO_3 respectively. In our endeavour to understand the formation of M-1 to M-5, we recommend for same order in the mechanism-3.4. The aromatic carboxyl unit as well as -O_2SOCH_2- functional groups in common (all data given in experimental section) and the corresponding spectra are presented in compound TS-1 and M-5 respectively. The sharp peak at 1726 to 1597cm^{-1} region for all compounds described to the C=O stretching mode of the end -CH_3 group characteristics of the formation of ditosylated diols. The Peak appeared around 3973 to 3880 cm^{-1} indicates the presence of carboxylic groups. The additional single in the FT-IR region at 1696-1694 cm^{-1} region indicates the C=O group in all macrocyclic compounds from M-1 to M-5.

Mass Spectra Investigation

The spectra of ditosylated diols for compounds form (TS-1 and TS-2), as well as the macro cyclic tetra lactones compounds from (M-1 to M-5) recorded (all data are given in experimental section) and the mass spectrum of compounds TS-1 and M-5 is depicted. The dominant middle peak indicates the existence of sodium (M+ Na^+) such observation of positive MS peak obtained with sodium ion adduct for the neutral compounds is not uncommon.

Thermal Analysis Technique

All these data of the long-established form (TS-1 and TS-2) as well as macrocyclic tetra lactones compounds from (M-1 to M-5) the proposed chemical formulas of all structures. For the accomplishment more information about the thermal constancy of the obtained compounds, TGA, DSC and DTG are performed. The thermal decomposition of the compounds TS-1 and TS-2 and macrocyclic tetra lactones compounds from (M-1 to M-5) take place in the Table 2. The first loss, located in the range of 20-140 °C, with 9.6 % weight loss is credited to the development of water molecules. The dehydration processes are interpreted by an endothermic peak in the DSC curve at 251.95°C and 245.22, at the same time, the DTG curve presents a melting process at 274.01°C and 283.58 by the exothermic peak for the compound of the TS-1 as shown in Figure 5. Similarly, the macrocyclic tetra lactones compound of M-5 as shown in Figure 6 respectively. The tetra lactones are decomposed completely between 190 and 697 °C. The experimental values for the mass loss in this stage are 70.39 % and 85.58 %, while the calculated values are 73.40 % and 85.42 %, respectively. When the temperature is above 697 °C, the TGA curve presents a platform, implying there is no weight changing in this range. The thermal analysis of the samples from Syntheses of (TS-1 & TS-2) as well as macrocyclic tetra lactones compounds from (M-1 to M-5) were carried out on Mettler Toledo USA make (Model TGA/DSC[1], STAR[e] System SW 9.20.), from temperature range 25 to 850°C using platinum crucible under nitrogen atmosphere (40-50 cm^3/min) shown in Table 3 given below.

Table 3. The character parameters of TGA, DTG and DSC curves of Syntheses of (TS-1 and TS-2) as well as macro cyclic tetra lactones compounds from (M-1 to M-5)

Sr. No.	Comp.	Stage	TGA		DTG	DSC	Entry	Assignments
			T_{range}/°C	Total mass loss (%) mg	Peaks/°C	Peaks/°C		
Syntheses of Ditosylated diols with P-toluenesulfonyl chloride and various glycols (TS-1 & TS-2).								
1	$C_{18}H_{22}O_7S_2Na$	I II III	20-150 240-250 350-780	(101) 9.69 (28.5) 2.72 (4.0) 0.38	86.04 256.7 640.93	89.4 (endo) 247(exo), 251(endo) 490 (endo)	TS-1	• Loss of H_2O. • Decomposition of $-O_2SOCH_2$ group.
2	$C_{20}H_{26}O_8S_2Na$	I II III	20-150 190-270 400-800	(100) 11.4 (23.5) 2.66 (10.5) 1.20	75.17 238 800	83.2 (endo) 258(endo) 800 (exo)	TS-2	• Loss of H_2O. • Decomposition of $-O_2SOCH_2$ group.
Syntheses of Macro cyclic tetra lactones with various diacids and Ditosylated diols (M-1 to M-5).								
1	$C_{26}H_{24}O_{10}$	I II III IV	- - 130-160 170-254 613-687	- - (9.36) 1.07 (6.45) 0.86 (1.33) 0.54	- 236.52 311.40 484.83	- 170 (endo) 215 (endo) 576(exo)	M-1	- • Decomposition to carbon residue. • Decomposition

								to oxygen residue
2	$C_{30}H_{34}O_{10}$	I II III	50-115 198-377 414-458	(100)15.5 (59.64)6.56 (7.40)0.27	63.74 342.82492.17	201(endo) 289(endo) 564 (endo)	M-2	• Loss of H_2O. • Decomposition to carbon residue. • Decomposition to oxygen residue
3	$C_{26}H_{24}O_{10}$	I II III	20-120 125-265 288-463	(100)17.8 (48.0)11.0 (52.9)19.16	87.14 278.87 371.81	116(endo) 254(endo), 376(exo) 482(endo)	M-3	• Loss of H_2O. • Decomposition to carbon residue. • Decomposition to oxygen residue
4	$C_{28}H_{30}O_{10}$	I II III	- 120-225 230-390	- (16.76)1.40 (2.00)0.16	- 225.56 371.81	164(endo) 228(endo) 664(exo)	M-4	- • Decomposition to carbon residue. • Decomposition to oxygen residue
5	$C_{25}H_{26}O_{10}$	I II III	- - 150-193 430-450	- - (42.5)19.47 (35.1) 16.0	- 244.32 599.6	118 (endo) 246 (endo) 606 (exo), 801(endo)	M-5	• Decomposition to carbon residue. • Decomposition to oxygen residue

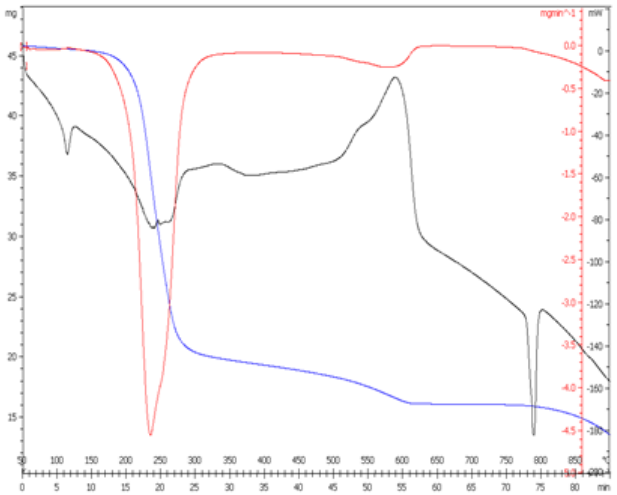


Figure 5. The simultaneous TGA, DSC and DTA Curves of Compound TS-1

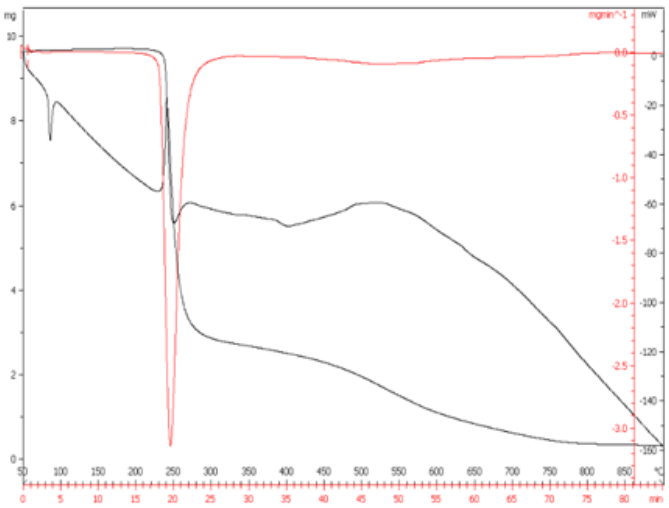


Figure 6. The simultaneous TGA, DSC and DTA curves of compound M-5

Electron Microscopic Observation Investigation

Further to examine their morphology using FE-SEM (Figure 7). The FE-SEM micrograph obtained with gold cotted for all ditosylated diols for compounds form (TS-1 and TS-2) as well as macrocyclic tetra lactones compounds from (M-1 to M-5) recorded in the solid state. All compounds showed the formation of bone, and sharp rigid plate type architecture measured with an understanding from the weak -O_2SOCH_2…. O and O–H. . .O syntheses of macrocyclic tetra lactones with various diacids and ditosylated diols, an attempt has been made to derived a reasonable enlargement mechanism to understand the morphological difference obtained by FE-SEM image. The benzene ring and the flexibility at the central spacer with various diacids and ditosylated diols section combinedly facilitate to interconnect the adjacent molecules and form a single stranded bone structures (TS-1 and TS-2) through its strong intermolecular carboxylic hydrogen bond shown in compound (TS-1), (Figure 8a and 8b). Similarly, the C-H…O interaction mediated through C=O group of the ester unit from (M-1 to M-5), involves in strong inter interaction with several dimension with (20.18 µm × 1.86 µm × 728.5 nm) the neighboring the dimensionality of the molecules packing. The increase in the number of carbon and the flexibility on the spacer moiety, increase the pitch distance of the bone, sharp rigid plate strand in the order TS-1 <M-5. In order to forms impersonate fascinatingly structures, measured through FE-SEM is a micrometer range from (5.63–12.46µm), the corresponding bones type structure show the hollowness in the molecular structure (TS-1 and TS-2) in few Angstrom. It is considered as essential to understanding the mechanism through which the supramolecular self-assembly takes place. In full of meaning humorously structures strong head group interactions, caused by hydrogen bonding with aromatic interactions, are expected to play an important role in the formation of a compound from (M-1 to M-5).

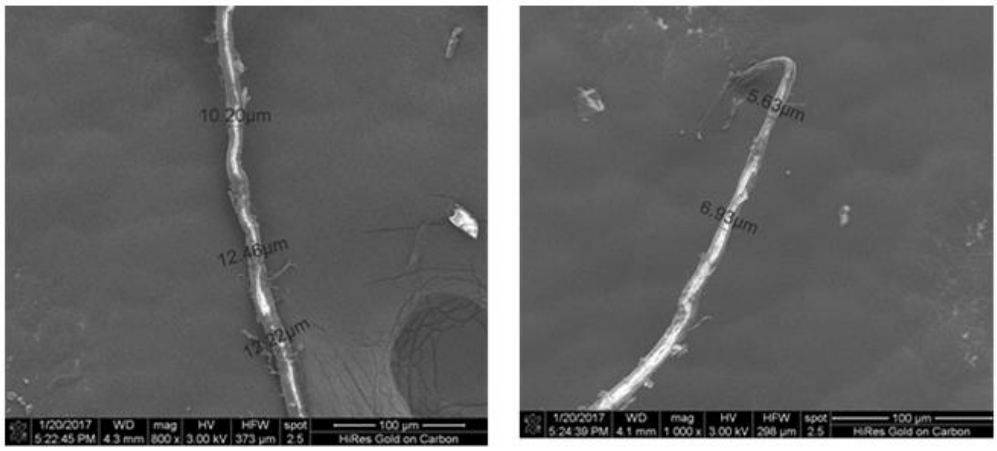


Figure 7. (a) The FE-SEM image (TS-1), (b) The FE-SEM image (TS-2)

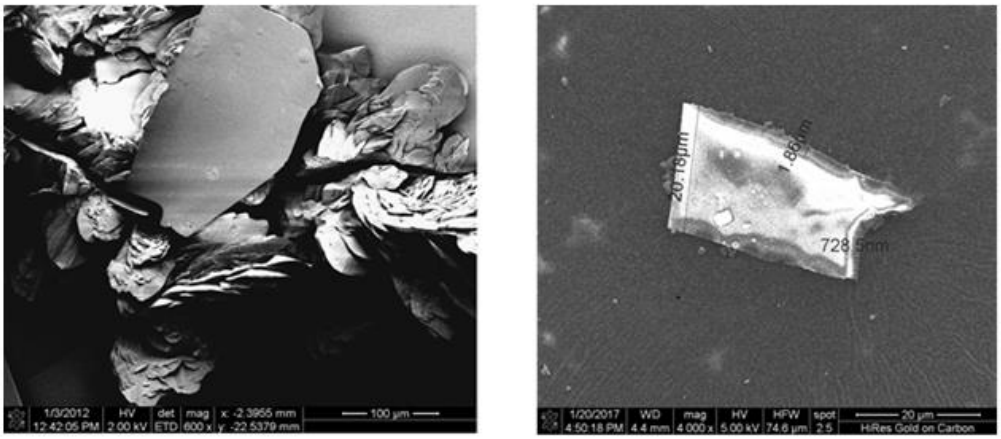


Figure 8. (a) The FE-SEM image (M-1), (b) The FE-SEM image (M-5)

CONCLUSION

In this work, a simple synthetic method has been designed that produces two new ditosylated diols (TS-1&TS-2) and five macrocyclic tetra lactones compounds from (M-1 to M-5) possessing is known to provide lactone-based macrocyclic compounds are synthesized and their appropriate the synthesis of macrocycles with lactones were performed by treating the with various diacids and ditosylated diols. Chemical formulas of all compounds are established by spectroscopic techniques and elemental analyses. It is thought that this thermal stability ditosylated diols (TS-1&TS-2) and lactone-based compounds from (M-1 to M-5) could be useful, especially in extraction studies, and the crucial aspect for this aim. In the next study, these compounds will be used in an extraction process for making complexes in water with transition-metal cations, such as Co^{2+}, Ni^{2+}, Cu^{2+}, and Zn^{2+} through molecular self-assembly.

REFERENCES

[1] Still WC; Galynker I. *Tetrahedron*. **1981**, 37, 3981-3996.
[2] Still WC; Galynker I. *Tetrahedron*. **1981**, 37, 3970-3979.
[3] Dunitz JD. Perspectives in Structural Chemistry by JD Dunitz, JA Ibers editor. (2nd edn.), Wiley Publishers, New York, **1968.**
[4] Jenkins AD, Suter UW. *Pure Appl Chem.* **1996,** 68 (12), 2287–2311.
[5] Weller M. Inorganic Chemistry, 6th edition, Oxford University Press, **2014.**
[6] Melson GA. Coordination Chemistry of Macrocyclic Compounds. Plenum Press, New York, **1979.**
[7] Bilgin A; Ertem B; Agın DF; Gok Y; Karslıoğlu S. *Polyhedron*. **2006,** 25, 3165.
[8] Arisa J; Rojrit R; Mongkol S. *Tetrahedron Lett*. **2007,** 48, 1817.
[9] Cakır U; Ozer M; Icen MA; Ugras HI; Bulut M. *Dyes and Pig*. **2004,** 60, 177.
[10] Lalot J; Manier G; Stasik I; Demailly G; Beaupere D. *Carbohydr Res*. **2001,** 335, 55–61.
[11] Chaveriat L; Stasik I; Demailly G; Beaupe`re D. *Carbohydr Res*. **2004,** 339, 1817–1821.
[12] Zalipsky S; Harris JM. *J Am Chem Soc*. **1997**, 680.
[13] Gallant AJ; Patrick BO; MacLachlan MJ. *J Org Chem.* **2004**, 69, 8739–8744.
[14] Wessjohann AL; Rivera DG; Coll F. *J Org Chem.* **2006**, 71, 7521–7526.
[15] Haber J; Pamin K; Poitowicz J. *J Mol Catal A: Chem*. **2004**, 224, 153–159.
[16] Selvakumar PM; Suresh E; Subramanian PS. *J Mol Struct*. **2009**, 919, 72–78.
[17] Shimizu T; Masuda M; Minamikawa H. *Chem Rev*. **2005**, 105, 1401–1443.
[18] Estroff LA; Hamilton AD. *Chem Rev*. **2004**, 104, 1201–1218.
[19] Muthusamy S; Gnanaprakasam B; Suresh E. *Org Lett*. **2006**, 8, 1913–1916.
[20] Chen Y; McDaid P; Deng L. *Chem Rev*. **2003**, 103, 2965–2984.
[21] Seref Ertul; Mevlut Bayraki; Dincer Beduk A. *Iran J Chem Chem Eng*. **2008,** 27(4).
[22] Sivasankari G, Boobalan S, Thamizhini P, Sharmila A, Kavitha K; Archana S. *J Chem Pharm Res*. **2018**, 10(6), 7-15.