CHAPTER III
EXPERIMENTAL

3.1 Materials

Paraformaldehyde, 2,4-dimethylphenol, p-cresol, p-toluenesulfonyl chloride, methylamine and sodium sulfate anhydrous were purchased from Fluka, Switzerland. Sodium hydroxide, triethylamine, sodium bicarbonate, potassium hydroxide, and isopropanol were obtained from Carlo Erba, Italy. Diethyl ether, 1,4-dioxane, acetonitrile, acetone, chloroform, tetrahydrofuran, dimethyl formamide were provided from Labscan, Ireland. Deuterated chloroform and pentaerythritol were purchased from Sigma-Aldrich, Germany. All chemicals were used as received.

3.2 Equipment

Finishing reaction points were traced by Tin layer chromatography (TLC). Fourier transform infrared spectra (FTIR) were recorded by a Bruker Equinox55 infrared spectrometer in the range 4,000-650 cm^{-1} with 64 scans and a resolution of 4 cm^{-1}, ZnSe was used as the background material. Proton nuclear magnetic resonance (^{1}H-NMR) spectra and nuclear overhauser effect spectroscopy (NOESY) spectra were measured from a Broker Biospin Avance III 500MHz nuclear magnetic resonance spectrometer. Mass spectroscopy was analyzed by a Biosystems/Vestec electrospray ionization time-of-flight mass spectrometer (ESI-TOF MS).

3.3 Methodology

3.3.1 Preparation of Tetratosylated Pentaerythritol, **1**

The tetratosylated pentaerythritol, **1**, was prepared by heating the mixtures of pentaerythritol (0.27g, 2mmol) and sodium hydroxide (0.31g, 8mmol) in acetonitrile solution at 60°C for 1 h. Then, *p*-Toluenesulfonyl chloride (1.53g, 8mmol) was added, and the solution was stirred at room temperature for 3 days. The solvent was removed under vacuum to obtain the crude product. The crude product

was dissolved in chloroform and washed several times with water and dried over sodium sulfate anhydrous followed by recrystallization in chloroform to obtain **1**.

67% yield; R_f = 0.74 (5%MeOH in $CHCl_3$); white crystal product; FT-IR (KBr, cm^{-1}): 1468 cm^{-1} (w, disubstituted benzene), 1367 cm^{-1} (s, O=S=O stretching), 981 cm^{-1} (vs, S-O-C), 884 cm^{-1} (s, C-C-C); ^{1}H-NMR (500 MHz, $CDCl_3$, ppm): 2.52 (12H, S-Ar-**CH_3**), 3.92 (8H, C-**CH_2**-O), 7.56 (8H, meta-Ar-**H**), 7.87 (8H, othro-Ar-**H**); ESI (MeOH, m/z): 775.04 (core molecule + $Na)^+$.

3.3.2 Preparation of 3,6-dimethyl-3,4-dihydro-2H-benzole-1,3-oxazine (Benzoxazine Monomer)

Benzoxazine monomer was prepared as reported in the past (Chirachanchai *et al.*, 2009). Methylamine (0.35 mL, 10 mmol) was added dropwisely into paraformaldehyde solution (1.52 mL, 20 mmol) in dioxane. Then, *p*-cresol (1.08 g, 10 mmol) was added and refluxed at 110 °C for 6 h. The solution obtained was dissolved in diethyl ether and extracted with 0.1 N sodium hydroxide solution (10 mLx2) and water (10 mLx2). The product was dried with sodium sulfate anhydrous and the solvent was removed to obtain the yellowish crude product.

90% yield; R_f = 0.62 (5%MeOH in $CHCl_3$); yellowish crude product; FT-IR (ZnSe, cm^{-1}): 3000–2850 cm^{-1} (w, C-H), 1613 cm^{-1} (m, C=C stretching), 1506 cm^{-1} (s, trisubstituted benzene), 1225 cm^{-1} (vs, C-O-C antisymmetric stretching), 917 cm^{-1} (b, O-C-N); ^{1}H-NMR(500 MHz, $CDCl_3$, ppm): 2.34 (3H, para-**CH_3**), 2.77 (3H, oxazine-**CH_3**), 4.01 (2H, Ar-**CH_2**-N), 4.99 (O-**CH_2**-N), 6.67, 6.90, and 7.03 (3H, Ar-**H**).

3.3.3 Preparation of N,N-Bis(2-hydroxy-5-methyl benzyl)methylamine (Benzoxazine Dimer), **2**

Benzoxazine dimers, **2**, was prepared as reported in the past.[9] In brief, the mixtures of benzoxazine monomer and *p*-cresol (molar ratio 1:1) were stirred at 60 °C for 3 h. The mixture was allowed to react until the solution became viscous. The viscous solution was washed with diethyl ether and was dried over sodium sulfate anhydrous. The solvent was removed under vacuum to obtain the crude product. The crude product was recrystallized in isopropanol to obtain white crystal of **2**.

87% yield; R_f = 0.32 (5%MeOH in $CHCl_3$); colorless crystal product; FT-IR (KBr, cm^{-1}): 3338 cm^{-1} (s, O-H stretching), 3008–2853 cm^{-1} (m, C-H stretching), 1502 cm^{-1} (s, trisubstituted benzene), 1246 cm^{-1}(m-s, C-OH in plane bending), 950 (w, trisubstituted benzene), 860 cm^{-1}(s, out-of-plane C-H deformations); ^{1}H-NMR (500 MHz, $CDCl_3$, ppm): 2.25(6H, para-**CH_3**), 2.30 (3H, N-**CH_3**), 3.78 (4H, Ar-**CH_2**-N), 6.54, 6.91 and 7.03 (6H, Ar-**H**).

3.3.4 Preparation of Star-shaped Phenol (Model Reaction), **3**

Compound **1**, and *p*-cresol (molar ratio 1:4/ **1**: *p*-cresol) were reacted in acetonitrile with refluxing in addition of triethylamine (molar ratio 1:4:4) (with solid content about 30%). The completion of the reaction was followed by TLC which indicated the reaction time of 36 h. The solvent was removed, and the crude product was recrystallized in the mixed solvent of isopropanol and chloroform (2:1 v/v) to obtain **3**. Similarly, the reactions were carried out by using sodium bicarbonate, potassium hydroxide, sodium hydroxide instead of triethylamine to study the effect of additional base on the reaction.

Furthermore, isopropanol and other polar aprotic solvents; tetrahydrofuran, acetone, and dimethyl formamide, were used to study the effect of temperatures and types of solvents on the reaction.

41% yield; white crystal product; FT-IR (KBr, cm^{-1}): 3032-2925 cm^{-1} (m, C-H stretching), 1613 cm^{-1} (m, C=C aromatic ring), 1512 cm^{-1} (vs, disubstituted benzene ring of phenol), 1472 cm^{-1} (m, disubstituted benzene of tosyl), 1365 cm^{-1} (vs, O=S=O streching), 1235 cm^{-1} (s, C-O-C alkyl aryl ethers), 1054 cm^{-1} (m, R(alkyl)-C-O streching), 982 cm^{-1} (s, S-O-C), 884 cm^{-1} (s, C-C-C), 860 cm^{-1}(s, out-of-plane C-H deformations); ^{1}H-NMR ($CDCl_3$, ppm): 2.31 (6H, Ar-**CH_3**), 2.38 (6H, Ar-**CH_3**), 3.903 (4H, **CH_2**-O-S), 4.232 (4H, **CH_2**-O-Ar), 6.57 (4H, O-othro-Ar-**H**), 7.04 (4H, O-meta-Ar-**H**), 7.19 (4H, S-othro-Ar-**H**), 7.68 (4H, S-meta-Ar-**H**)); ESI (MeOH, m/z): 647.16 (2-arms phenol + Na)$^+$.

3.3.5 Star-shaped Benzoxazine Dimer, **4**

The compound **1** (0.753 g, 1 mmol) and **2** (1.085 g, 4 mmol) were prepared similar to **3** with various molar ratios of potassium hydroxide (0.225 g, 4 mmol and 0.450 g, 8 mmol). The solvent was removed in vacuum to obtain the crude products. The crude products were dissolved in chloroform and washed several times

with water and dried over sodium sulfate anhydrous followed by solvent removal to obtain crude of **4**.

In comparison, potassium hydroxide in dioxane was used to study the type of solvent which has similar point boiling with acetonitrile on the reaction. Because of studies of organic compounds, it was found that the nucleophilic substitute of thiols occurs in the presence of potassium carbonate in acetone at reflux temperature (Strunz, et al., 1988) so the other reaction was carried out by using potassium carbonate in acetone.