Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C

Supplementary Information

Electroconductive Membrane by Poly (hydroxymethyl 3, 4-Ethylenedioxythiophene-*co*-tetramethylene-N-hydroxyethyl adipamide)

Hamidreza Barghi[a, b,]*, Mohammad J Taherzadeh[a]

[a] *School of Engineering, University of Borås, SE-50190 Borås, Sweden*

[b] *Department of Chemical and Biological Engineering, Chalmers University of Technology, SE-41296 Gothenburg, Sweden*

*Corresponding author:

Tel: +46-33-435 4674

Fax: +46-33-435 4008

E-mail: Hamidreza.Barghi@hb.se

Characterization:

1H NMR (500 MHz) and 13C NMR (125 MHz) spectra were achieved from an Agilent VNMRS 500 MHz NMR system equipped with an HFX-probe (Agilent-USA). Tetramethylsilane was utilized as an internal reference with deuterated formic acid (DCOOD) as solvent. ATR-FTIR spectrums are obtained by Nicolet iS10, Thermo Scientific, Waltham, USA. TGA was performed using thermogravimetric analyzer apparatus TA Q 500, TA Instruments, Delaware, USA. The morphology micrographs are obtained by ESEM-FEI Quanta 200F, FEI Inc. USA which is equipped with a scintillating BSE detector in low pressure. AFM topography was investigated using AFM/SPM NETGERA prima, NT-MDT Inc. Russia. The apparatus was equipped with a Silicon SPM Probe, silicon cantilever for non-contact tapping mode, and detector side Au-coating silicone Pointprobe ® plus, Nanosensors, Inc. Switzerland for scanning membranes on the air mode at 20°C. The electrical resistancy was measured with a Keithley 6000 Ohm meter Picoammeter, Germany at 10 V, 2.5 mA and 20±2°C in $1cm^2$. The contact angle and surface tension were investigated using the Dynamic Absorption Tester (DAT) model Fibro DAT 1100 (Thwing-Albert Instrument Co. USA) using the pendant drop method. The instrument software was set up using the Owens & Wendt model [1]. Plasma apparatus (PDC-32G 18W Harrick Plasma, USA) was equipped with RF-coil to supply 700V DC, 15 mA current, 12 MHz radio frequency. Centrifugation was performed by centrifuge Vivaspin 20, Sartorius, Germany.

Materials:

Polyamide 46 (Stanley TW300, M_n ~ 24000 g/mol) was provided by DSM Scandinavia AB, Sweden. Formic acid was supplied by Sigma-Aldrich, purity ≥ 98%, d=1.22 g/mL at 25ºC. Dimethyl sulfoxide was from Sigma-Aldrich, purity ≥99.5%, d=1.10 g/mL at 25ºC. Anhydrous $AlCl_3$ was supplied by Sigma-Aldrich with purity ≥99.9%. Acetaldehyde was purchased from Sigma-Aldrich, purity ≥ 99%, d= 0.785 g/ml at 25ºC. Methanol was delivered from Fisher-Scientific, purity ≥ 99%, d= 0.791 g/ml at 25ºC. Ammonium hydroxide was diluted to a ~20% solution from a ammonium hydroxide 28% (Sigma-Aldrich, d= 0,9 g/mL at 25 °C). Hydroxymethyl 3,4-dioxythiophene monomer was purchased from CHEMOS GmbH (purity 95%, Mw. 172 .20 g/mol, mp 42- 46°C). Acetone was provided by Sigma-Aldrich (purity ≥ 99.5, 0.791 g/mL at 25°C).

Chemical structure

Infrared Spectra (FT-IR)

Transmittance percentages as: 3293 cm^{-1} (N-H, s), 3076 cm^{-1} (N-H, b), 2858 and 2945 (H-C-H, s), 1041 (C-O, s), 1044 (C-O-C, s), 1477 and 1478 (C=C, s), 1713 and 1721(C=O, s) 1612 (N-H, b), 1466 (CH_2, b), 1376 (CH_3, b), 1016 (C-O, s), 1279 (C-N,s), 925 (C-H, b), 818 (C-H, b), 1512 (N-H, b), 818 (C-H, b), 1239 (C-O, s), 1023 (C-O, s), 1142 (C-N,s).

d

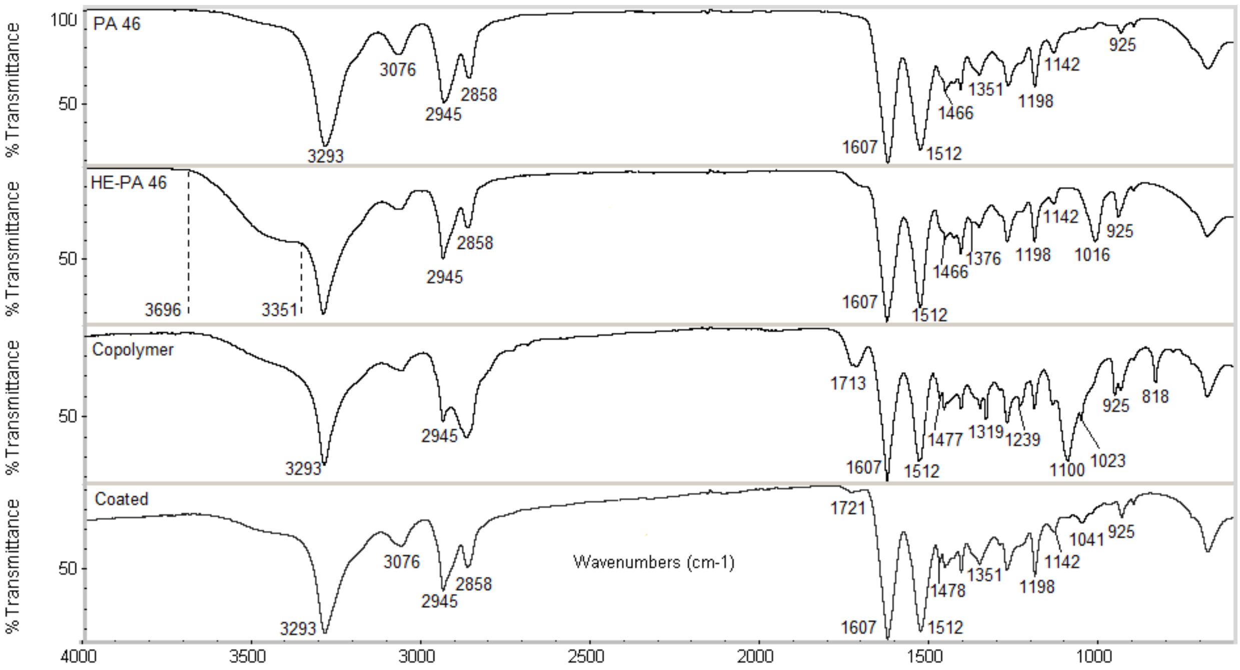

Figure S1: ATR-FTIR transmittance spectrums of PA 46, hydroxyethyl PA 46 (HE-PA 46), semi-conductive copolymer and surface plasma polymerized (coated) membranes.

NMR spectrums

^{1}H NMR (500 MHz, DCOOD; Me_4Si) of PA 46: δ 12.28-12-02 (m, 3H), 11.19 (s, 2H), 10.41 (d, *J* = 35.6 Hz, 3H), 8.91 -8.81 (m, 1H), 3.86 (s, 7H), 2.12-1.89 (m, 35H). ^{13}C NMR (126 MHz, DCOOD) of PA 46: δ 175.24, 171.22, 170.91, 160.06, 159.89, 159.72, 159.38, 159.36, 34.28, 31.68, 19.33, 18.88.

^{1}H NMR (500 MHz, DCOOD; Me_4Si) of hydroxyethyl PA 46: δ 12.04 (d, *J* = 48.6 Hz, 2H), 11.84-11.41 (m, 8H), 11.17 (d, *J* =36.4Hz, 1H), 10.42 (d, *J* =36.2 Hz, 2H), 3.82 (s, 20H), 3.82 (s, 43), 2.33-1.79 (m, 4H). ^{13}C NMR (126 MHz, DCOOD) of hydroxyethylated PA 46: δ 170.91, 160.10, 160.06, 159.91, 159.89, 159.80, 159.72, 159.48, 159.38, 159.37, 103.81, 31.68, 31.67, 19.33, 19.07, 18.88.

^{1}H NMR (500 MHz, DCOOD; Me_4Si) of semi-conductive copolymer: δ 10.60 (s, 371H), 8.99 (s,25H), 6.93 (s,1H), 6.48 (s,1H), 5.84 (s, 1H), 4.91-4.31 (m, 16H), 4.06 (s, 93H), 3.35-2.81(m, 95), 2.19 (dd, *J*=190.2, 25.1 Hz, 170H),0.99 (D, *J*=11.8Hz, 2H), 0.85 (s,1H). ^{13}C NMR (126 MHz, DCOOD) of semi-conductive copolymer: 207.69, 207.44, 205.13, 187.06, 186.34, 179.36, 177.23, 172.79, 166.44, 166.17 (Formic acid-D2), 165.90, 113.15, 40.00, 39.55, 35.35, 29.51, 25.96, 25.24, 25.12, 24.73.

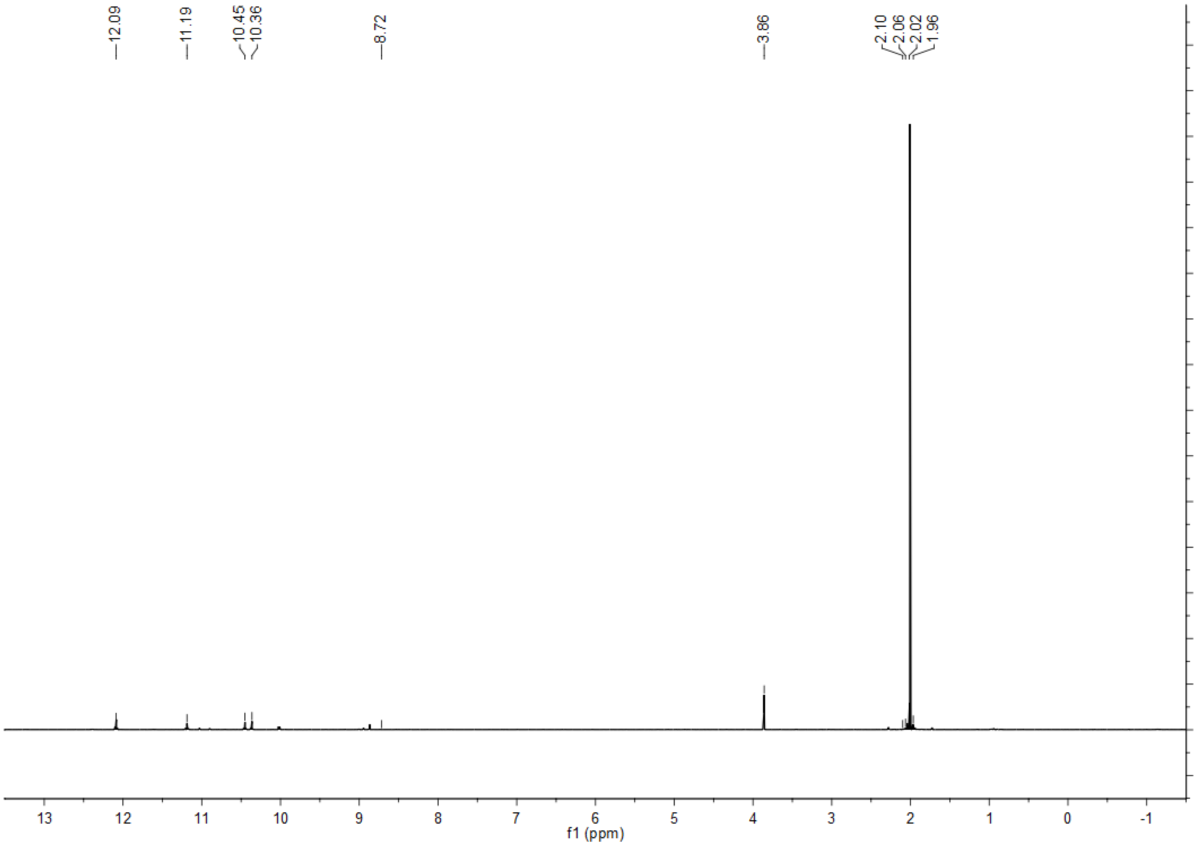

Figure S2: ^{1}H NMR spectra of PA 46 in DCOOD at 20ºC

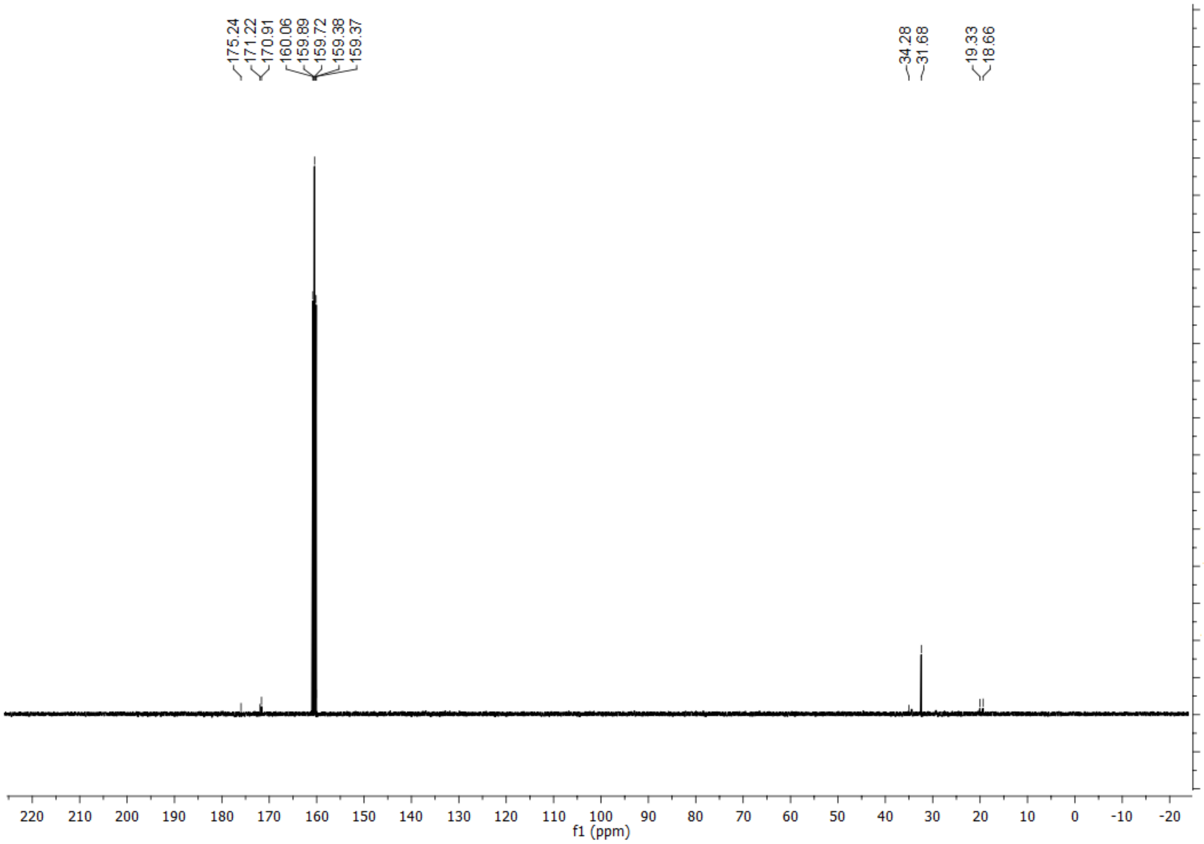

Figure S3: ^{13}C NMR spectra of PA 46 in DCOOD at 20ºC

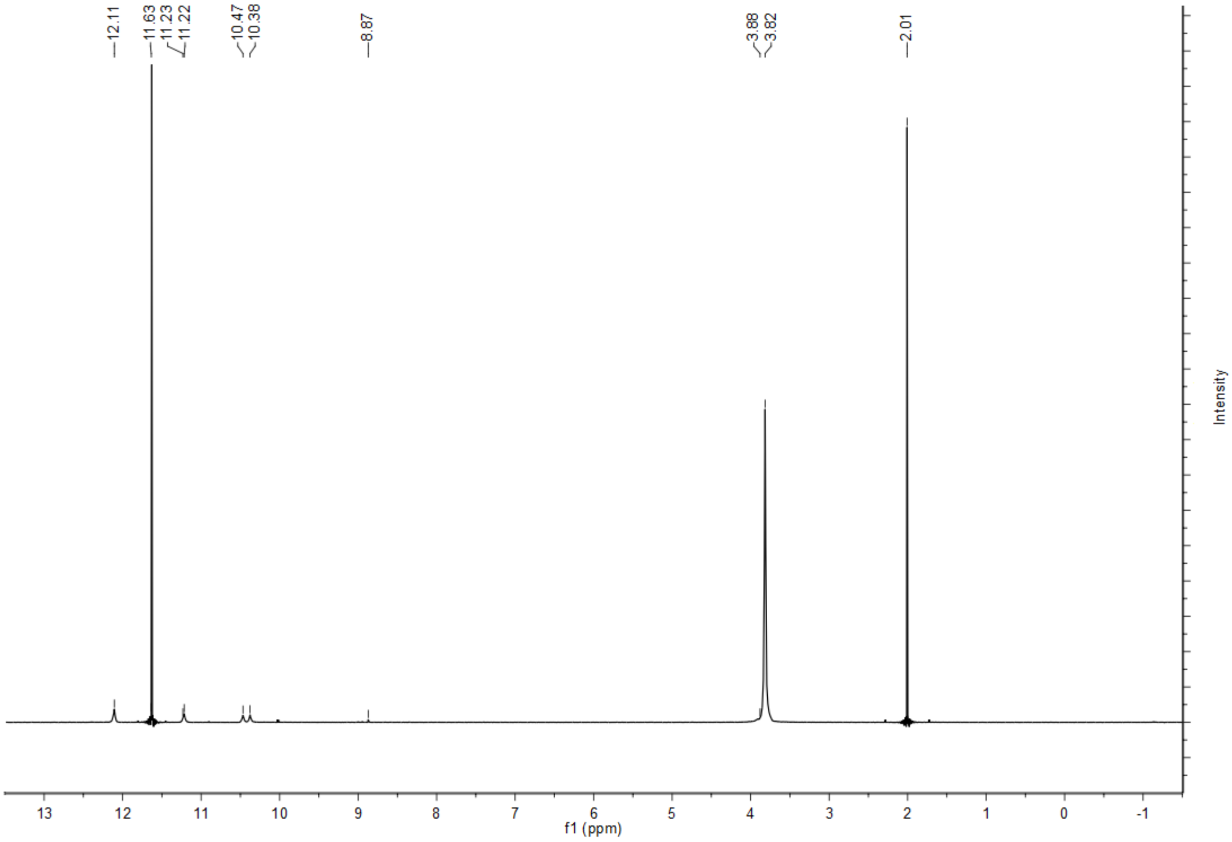

Figure S4: ^{1}H NMR of hydroxyethyl PA 46 in DCOOD at 20ºC

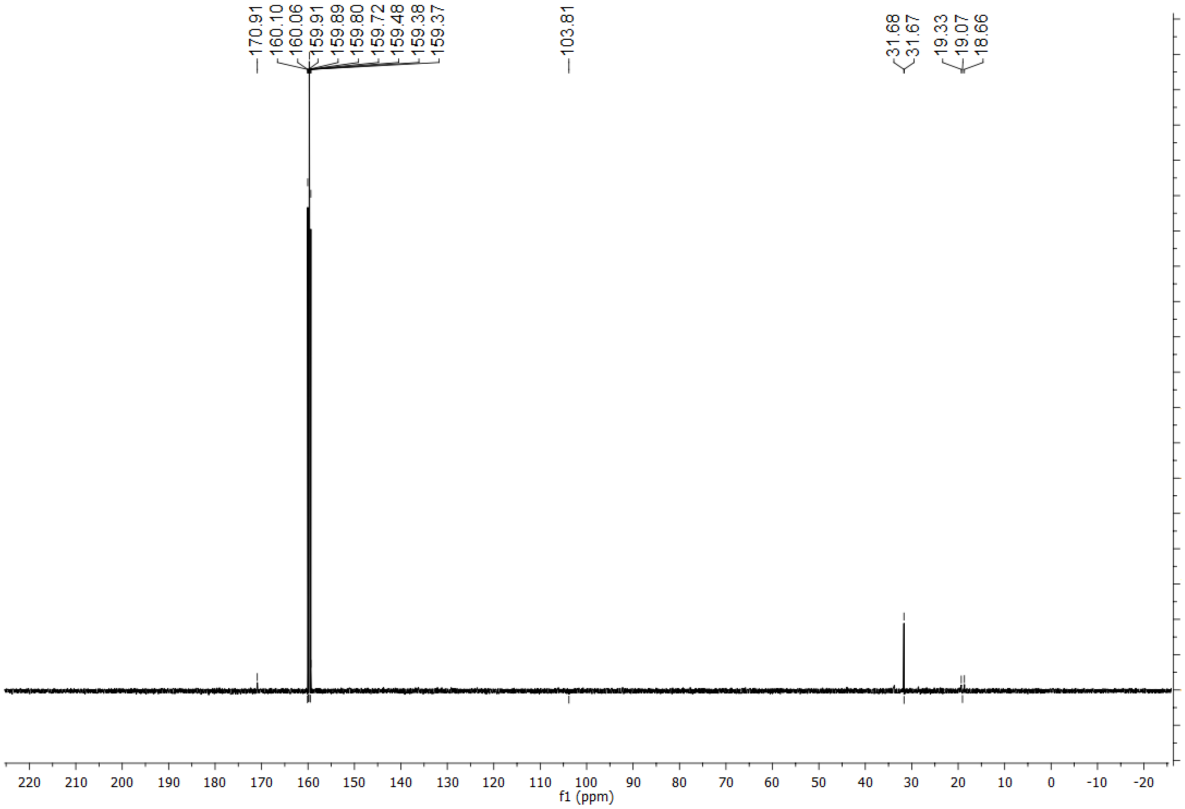

Figure S5: ^{13}C NMR hydroxyethyl PA 46 in DCOOD at 20ºC

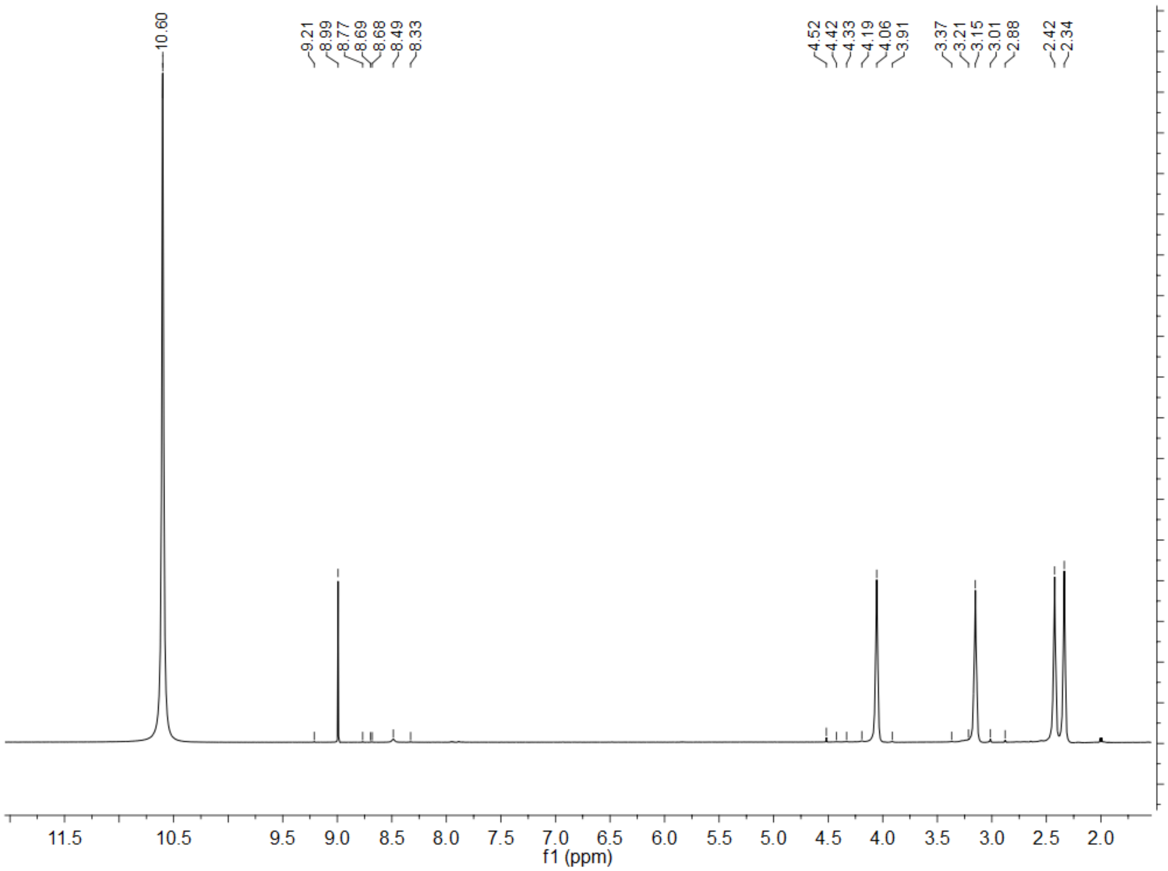

Figure S6: ^{1}H NMR of semi-conductive copolymer in DCOOD at 20ºC

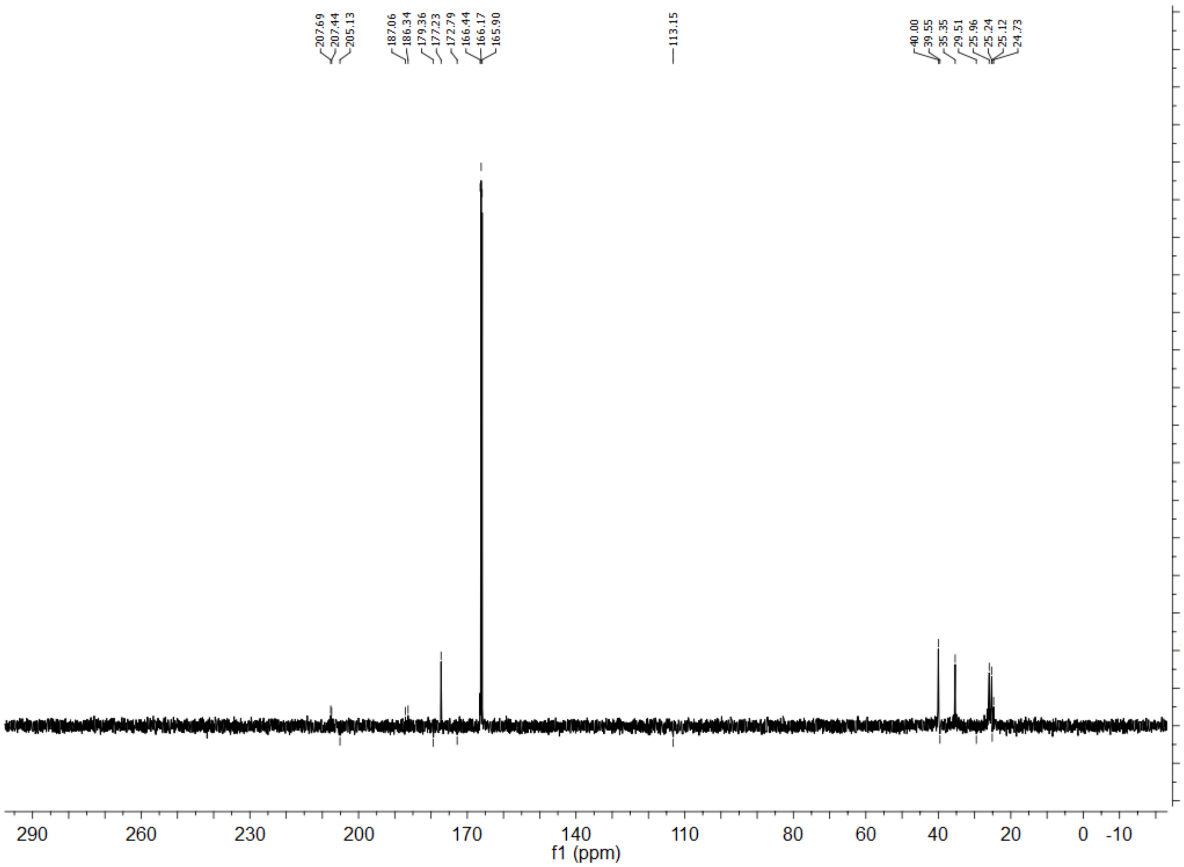

Figure S6: ^{13}C NMR of semi-conductive copolymer in DCOOD at 20ºC

Refrence

1. D. K. Owens and R. C. Wendt, *Journal of applied polymer science*, 1969, **13**, 1741–1747.