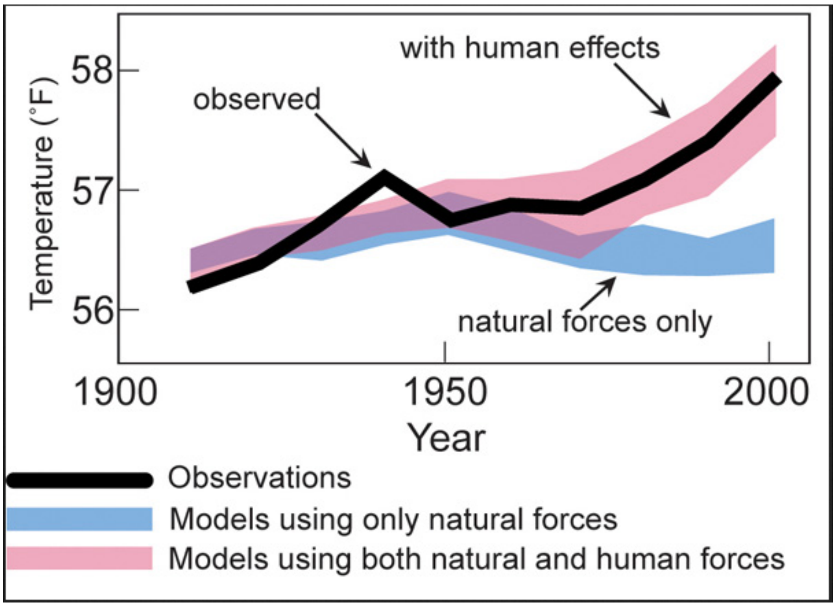

Figure 1: Temperature chances over the last century
(http://www.epa.gov/climatechange/science/causes.html (09.04.2014)).

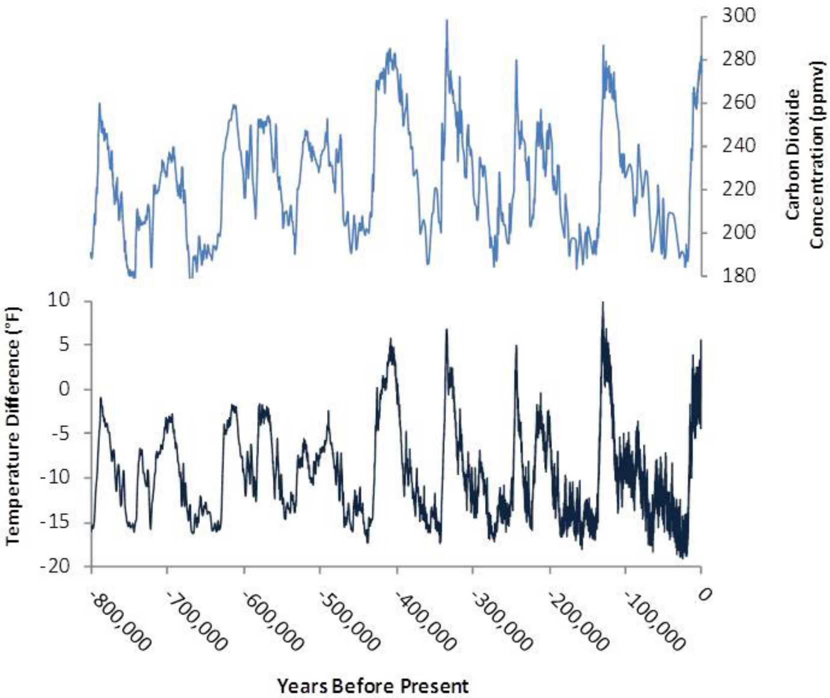

Figure 2: Correlation of Earth's surface temperature and the amount of carbon dioxide (http://www.epa.gov/climatechange/science/causes.html (09.04.2014)).

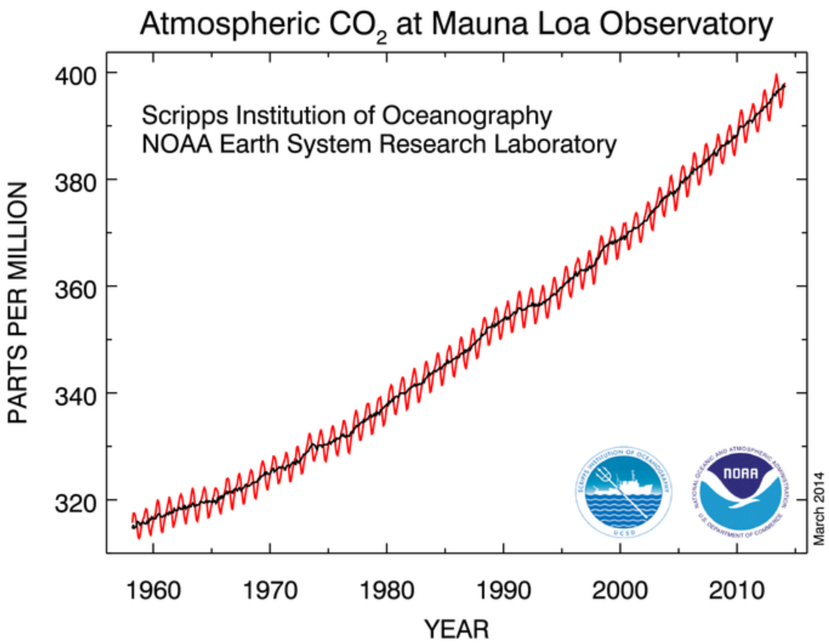

Figure 3: CO_2-measurement on Mauna Loa
(http://www.esrl.noaa.gov/gmd/ccgg/trends/index.html (09.04.2014)).

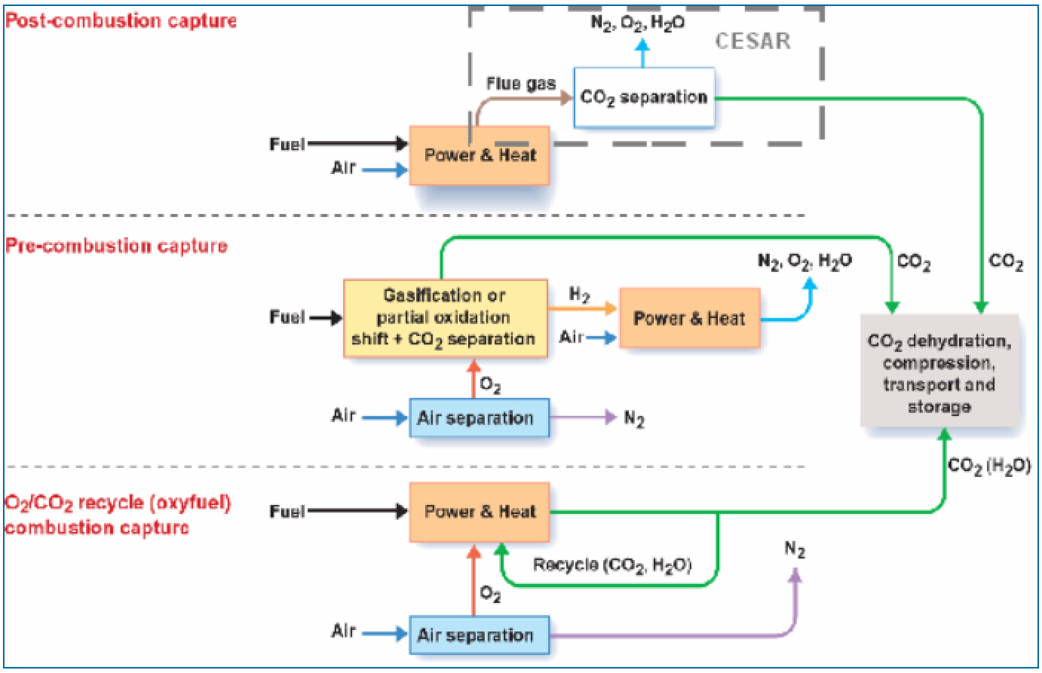

Figure 4: CO_2-separation principles (http://www.co2cesar.eu/site/en/about_objectives.php (15.05.2014)).

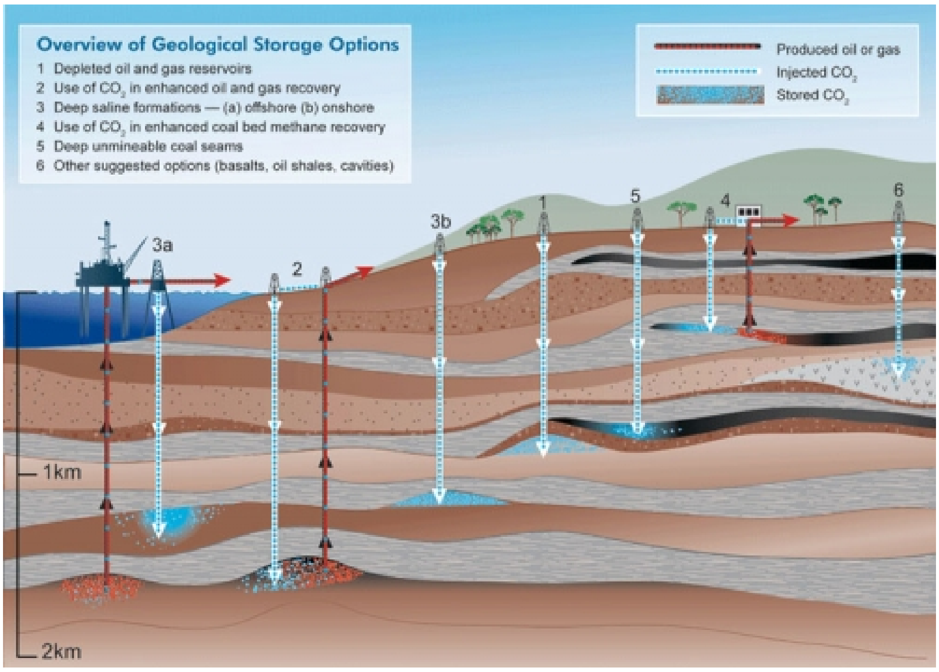

Figure 5: Geological storage options
(S. J. Friedann. *Carbon Capture and Storage*.).

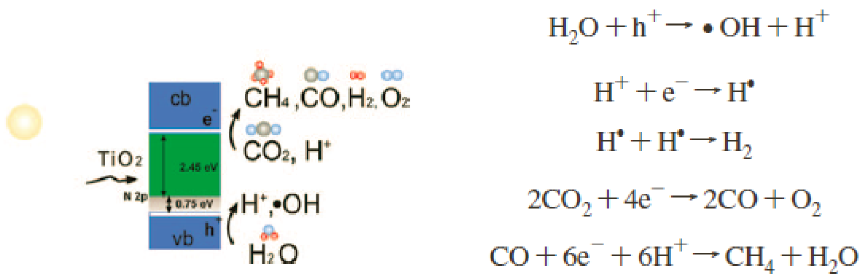

Figure 6: Sunlight-driven photocatalytic conversion of carbon dioxide to hydrocarbons
(O. K. Varghese, M. Paulose, T. J. LaTempa and C. A. Gries. *High-Rate Solar Photocatalytic Conversion of CO_2 and Water Vapor to Hydrocarbon Fuels*.).

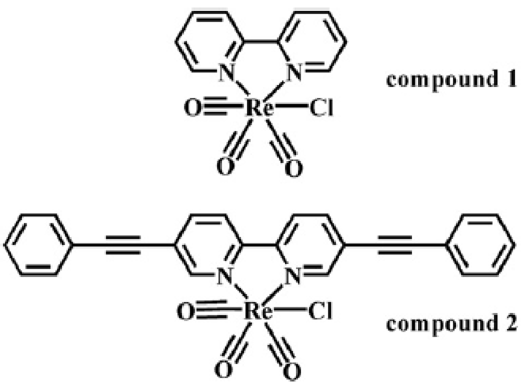

Figure 7: Chemical structure of (2,2′-bipyridyl)Re$(CO)_3$Cl (1) and (5,5′-bisphenylethynyl-2,2′-bipyridyl)Re$(CO)_3$Cl (2)
(E. Portenkirchner, K. Oppelt, Ch. Ulbricht, D. A. M. Egbe, H. Neugebauer, G. Knör and N. S. Sariciftci. *Electrocatalytic and photocatalytic reduction of carbon dioxide to carbon monoxide using the alkynyl-substituted rhenium(I) complex (5,5′-bisphenylethynyl-2,2′-bipyridyl)Re$(CO)_3$Cl.*).

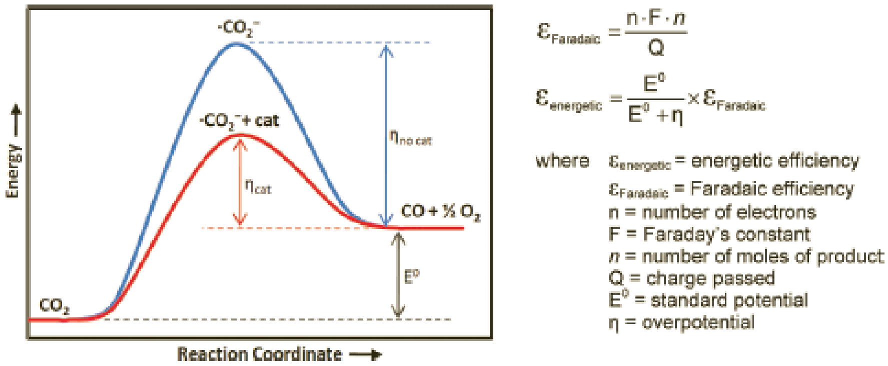

Figure 8: Qualitative reaction scheme for carbon dioxide conversion (D. T. Whipple and P. J. A. Kenis. *Prospects of CO_2 Utilization via Direct Heterogeneous Electrochemical Reduction*.).

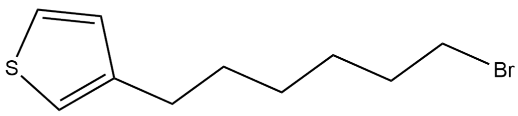

Figure 9: chemical structure of 3-(6-Bromohexyl)thiophene: **compound 1**

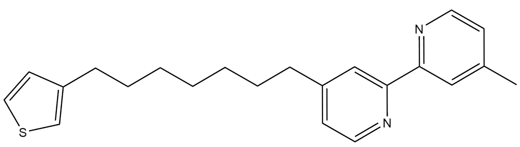

Figure 10: chemical structure of 4-Methyl-4′-(3-thienylheptyl)-2,2′-bipyridine: **compound 2**

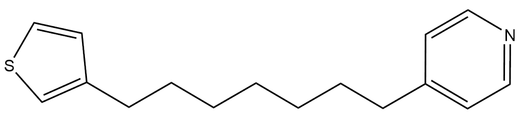

Figure 11: chemical structure of 4-(3-Thienylheptyl)-pyridine: **compound 3**

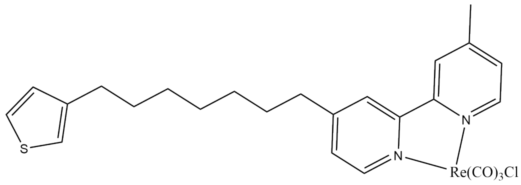

Figure 12: chemical structure of [4-Methyl-4′-(3-thienylheptyl)-2,2′-bipyridinyl)Re(CO)$_3$Cl]: **compound 4**

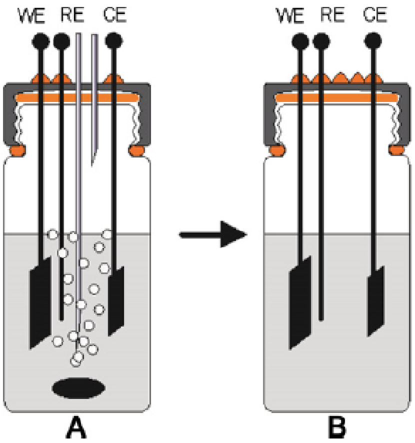

Figure 13: One-compartment cell for purging with N_2 (A) and during electropolymerization a closed system (B). Cells contain a working electrode (WE), a reference electrode (RE) and a counter electrode (CE)
(E. Portenkirchner, K. Oppelt, Ch. Ulbricht, D. A. M. Egbe, H. Neugebauer, G. Knör and N. S. Sariciftci. *Electrocatalytic and photocatalytic reduction of carbon dioxide to carbon monoxide using the alkynyl-substituted rhenium(I) complex (5,5′-bisphenylethynyl-2,2′-bipyridyl)Re(CO)$_3$Cl.*).

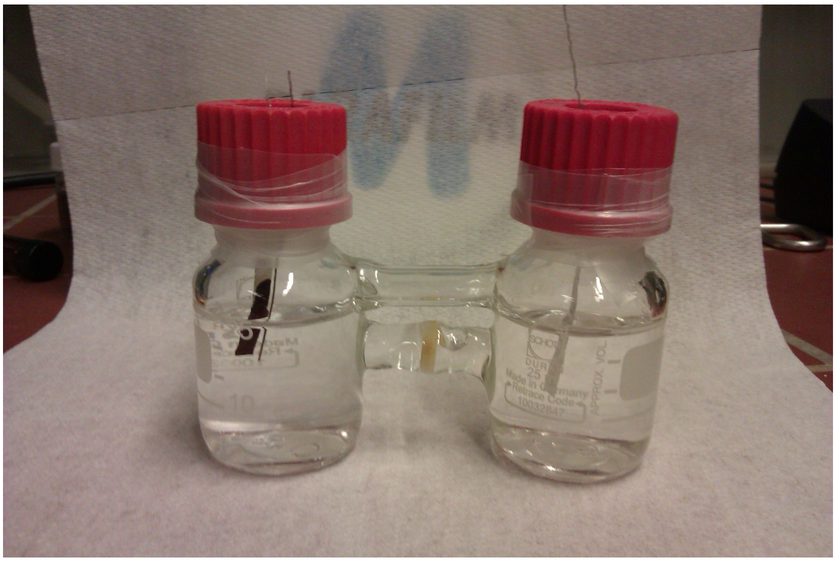

Figure 14: H-cell for electrolysis. The cell contains a WE (Pt-plate with polymeric film) and a Ag/AgCl-quasi RE on the one side of the cell and on the other side a CE (Pt-plate).

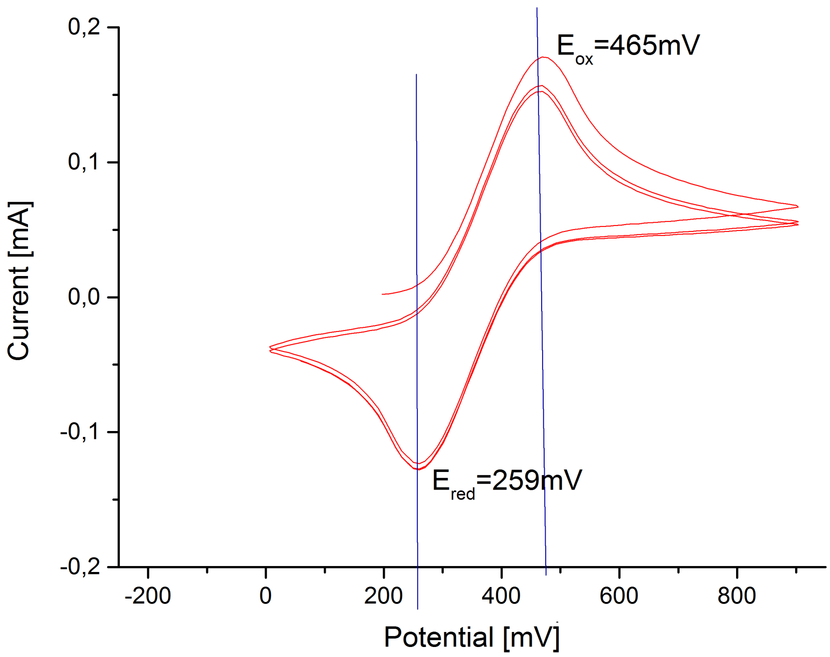

Figure 15: Cyclic voltammogram measured of Ferrocene with a scanrate of 10 mVs^{-1} in 0.1 M $TBAPF_6$ in acetonitrile.

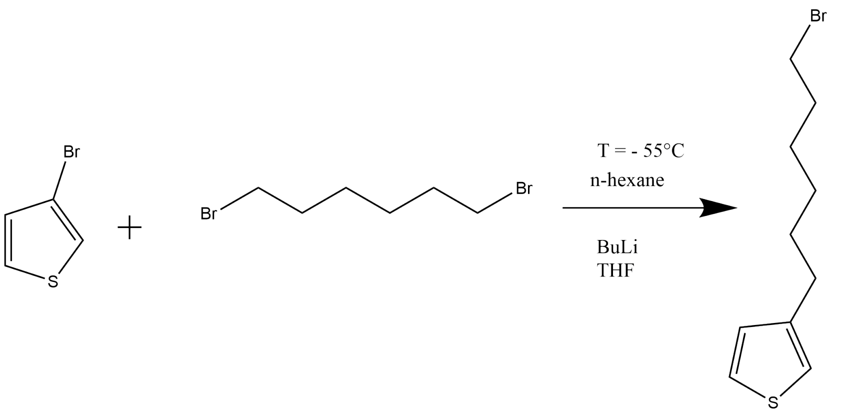

Figure 16: reaction scheme for synthesis of 3-(6-bromohexyl)thiophene

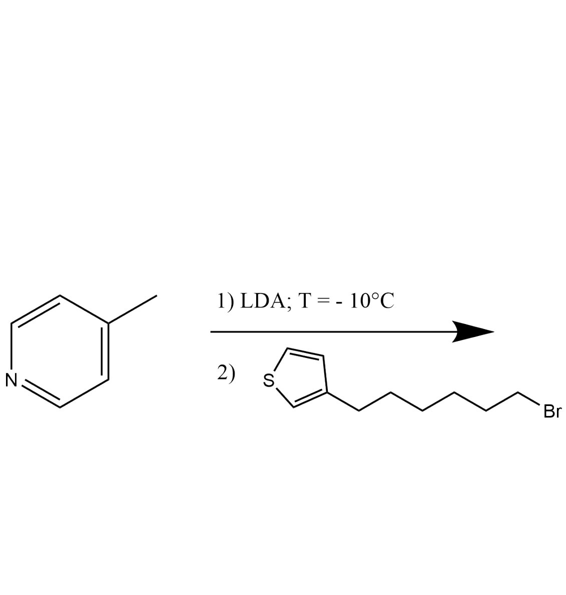

Figure 17: reaction scheme for synthesis of 4-(3-thienylheptyl)pyridine

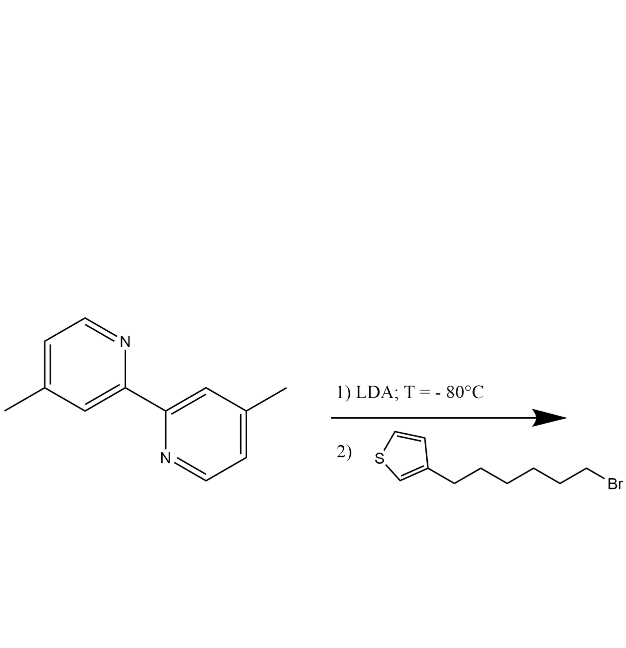

Figure 18: reaction scheme for synthesis of 4-methyl-4′-(3-thienylheptyl)-2,2′-bipyridine

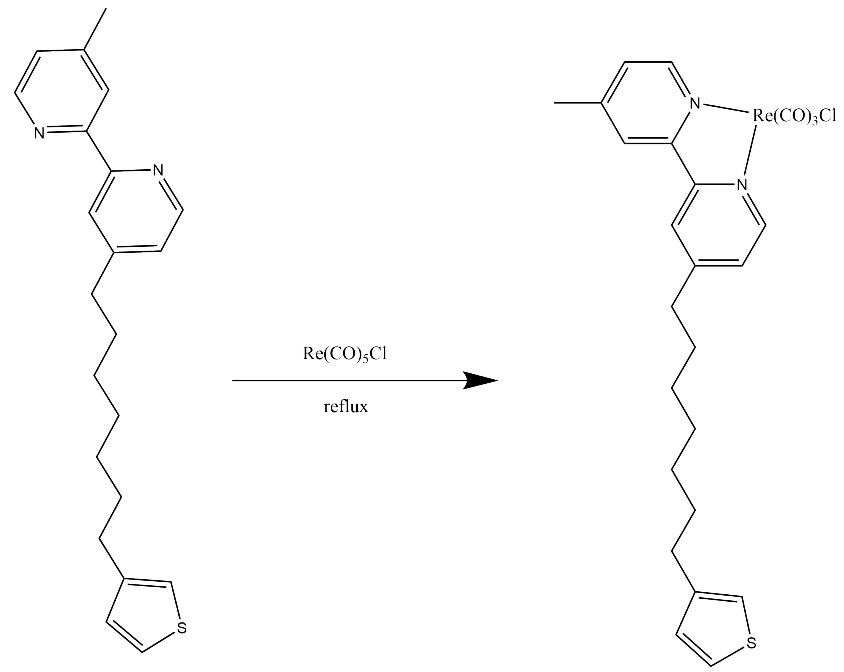

Figure 19: reaction scheme for synthesis of [4-methyl-4′-(3-thienylheptyl)-2,2′-bipyridinyl)Re(CO)$_3$Cl]

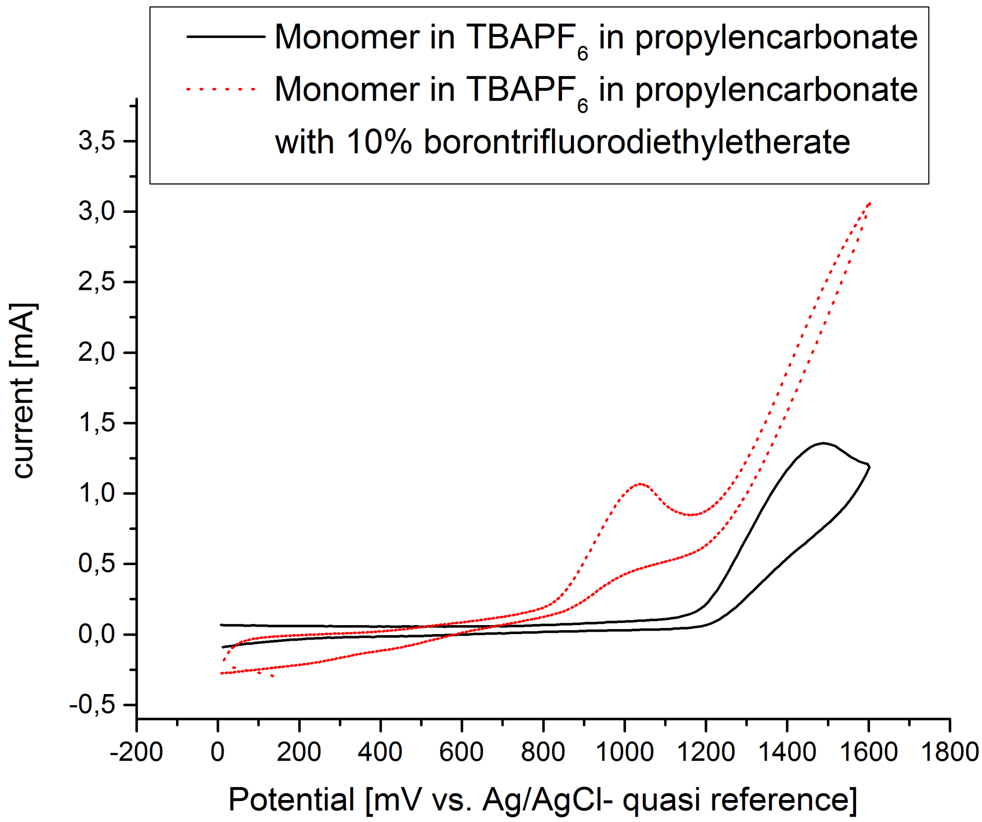

Figure 20: Scan from 0 mV to 1600 mV and back to 0 mV of [Re(4-Methyl-4′-(7-(3-thienyl)heptyl)-2,2′-bipyridinyl)$(CO)_3$Cl]
monomer in 0.1 M $TBAPF_6$ in propylencarbonate and after adding 10 % of BFEE with a scanrate of 100 mVs^{-1}.

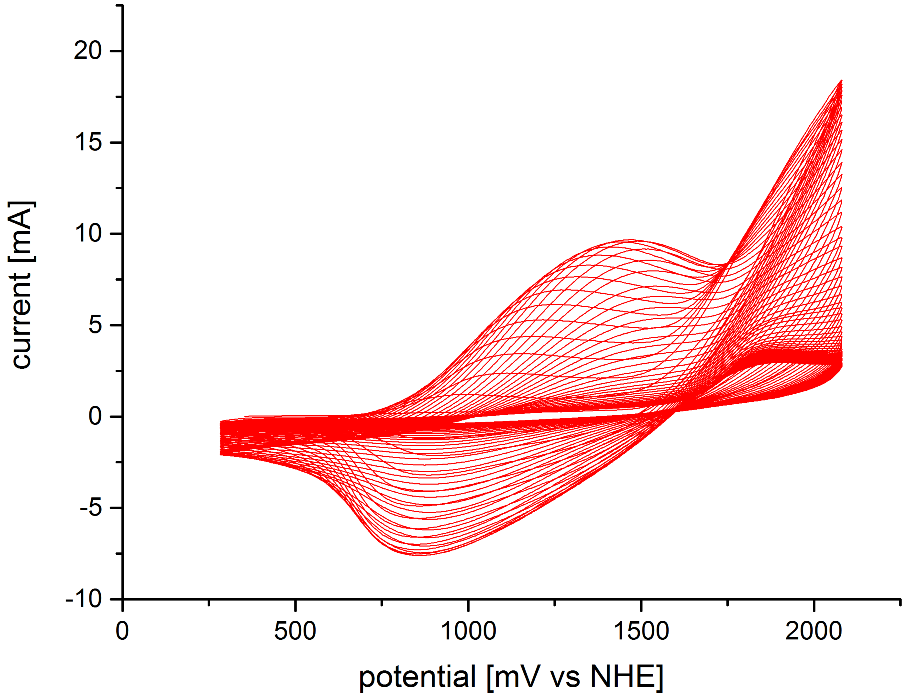

Figure 21: Potentiodynamic electropolymerization of 4-(3-Thienylheptyl)-pyridine. The polymerization is done in an one compartment-cell where a Pt-plate was used as working electrode. The counter electrode was also a Pt-plate and an Ag/AgCl-wire was used as quasi-reference electrode.

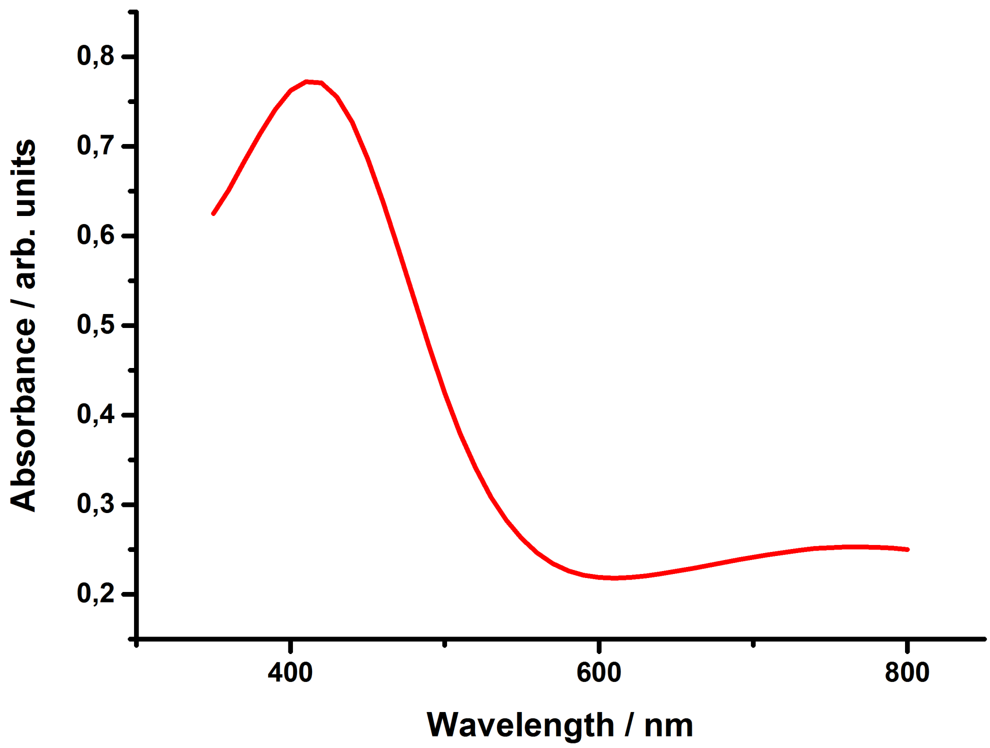

Figure 22: UV-vis measurement of pyridine functionalized poly- (thiophene) film on glass-ITO.

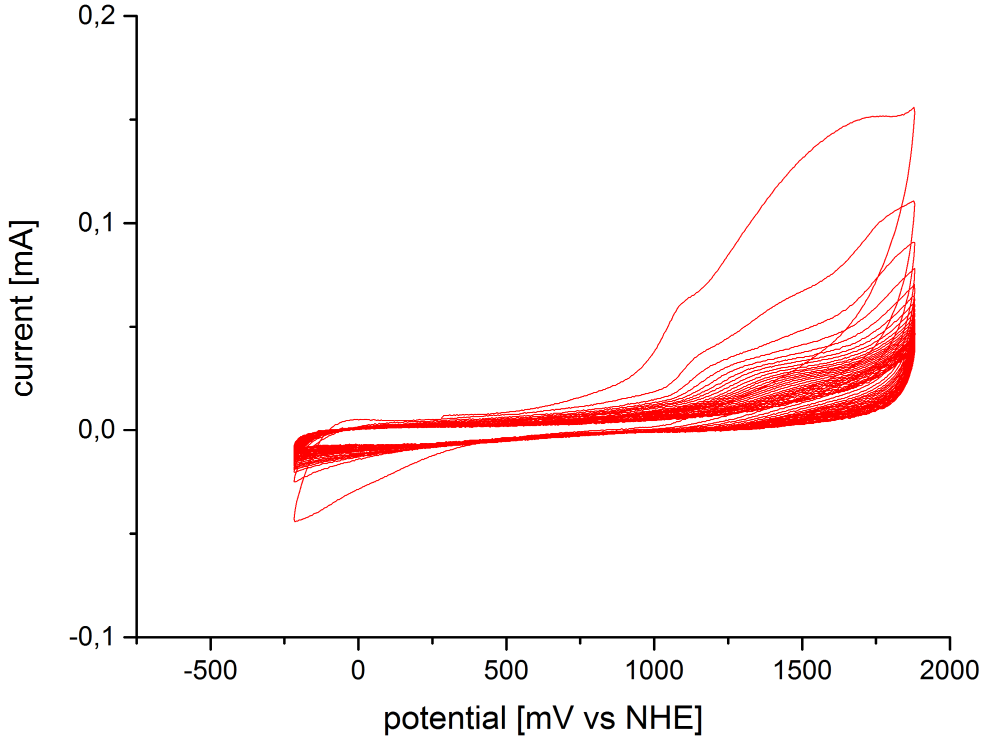

Figure 23: Potentiodynamic electropolymerization of 4-Methyl-4′-(7-(3-thienyl)heptyl)-2,2′-bipyridine with a scan rate of 50 mVs^{-1} in 0.1 M $TBAPF_6$ in propylen carbonate with 10% BFEE.

Figure 24: Complexation of poly-4-methyl-4′-(3-thienylheptyl)-2,2′-bipyridine film with $Re(CO)_5Cl$ in hot toluene.

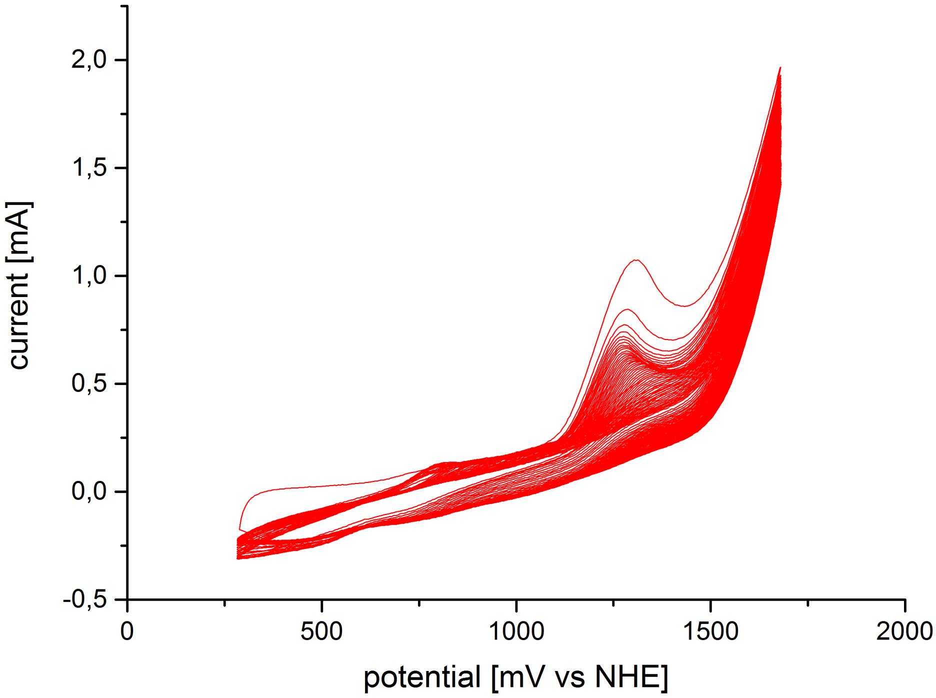

Figure 25: Potentiodynamic electropolymerization of [Re(4-Methyl-4′-(7-(3-thienyl)heptyl)-2,2′-bipyridinyl)$(CO)_3Cl$]. The polymerization is done in an one compartment-cell where a Pt-plate was used as working electrode. The counter electrode was also a Pt-plate and an Ag/AgCl-wire was used as quasi-reference electrode.

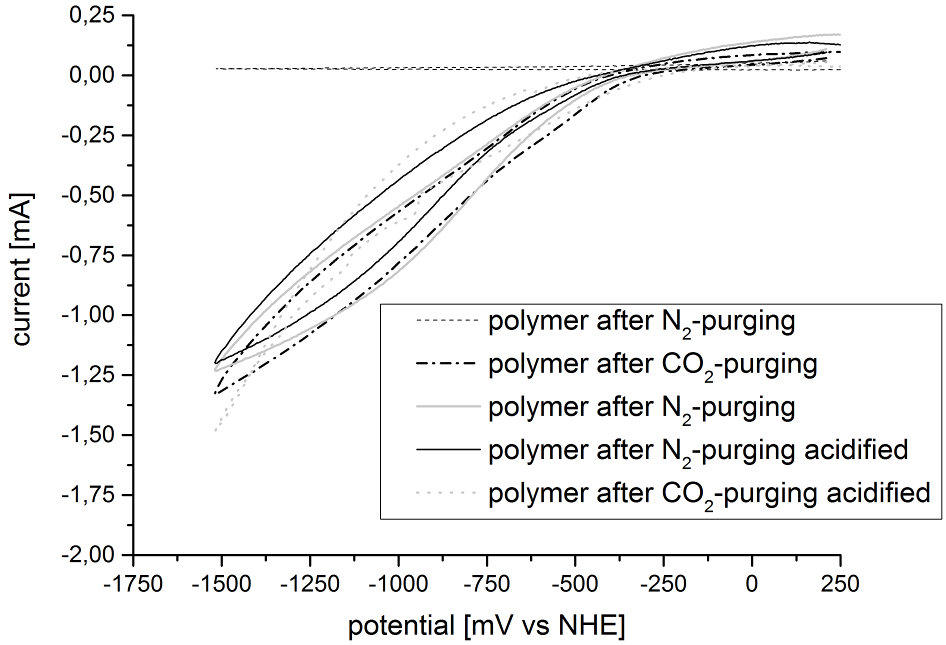

Figure 26: Cyclic voltammogram of polymeric-4-(3-Thienylheptyl)-pyridine-film measured with a scanrate of 50 mVs^{-1}. The polymerization is done in an one compartment-cell where a Pt-plate covert with the polymer was used as working electrode. The counter electrode was also a Pt-plate and an Ag/AgCl-wire was used as quasi-reference electrode. 0.1 M $TBAPF_6$ in acetonitrile is used as electrolyte.

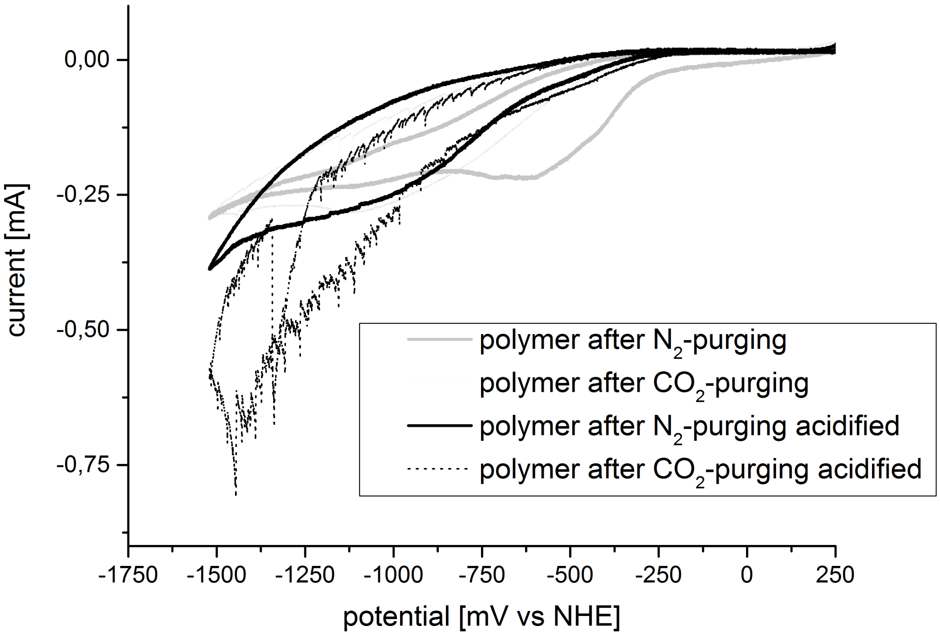

Figure 27: Cyclic voltammogram of polymeric-4-(3-Thienylheptyl)-pyridine-film measured with a scanrate of 1 mVs^{-1}. The polymerization is done in an one compartment-cell where a Pt-plate covert with the polymer was used as working electrode. The counter electrode was also a Pt-plate and an Ag/AgCl-wire was used as quasi-reference electrode. 0.1 M $TBAPF_6$ in acetonitrile is used as electrolyte.

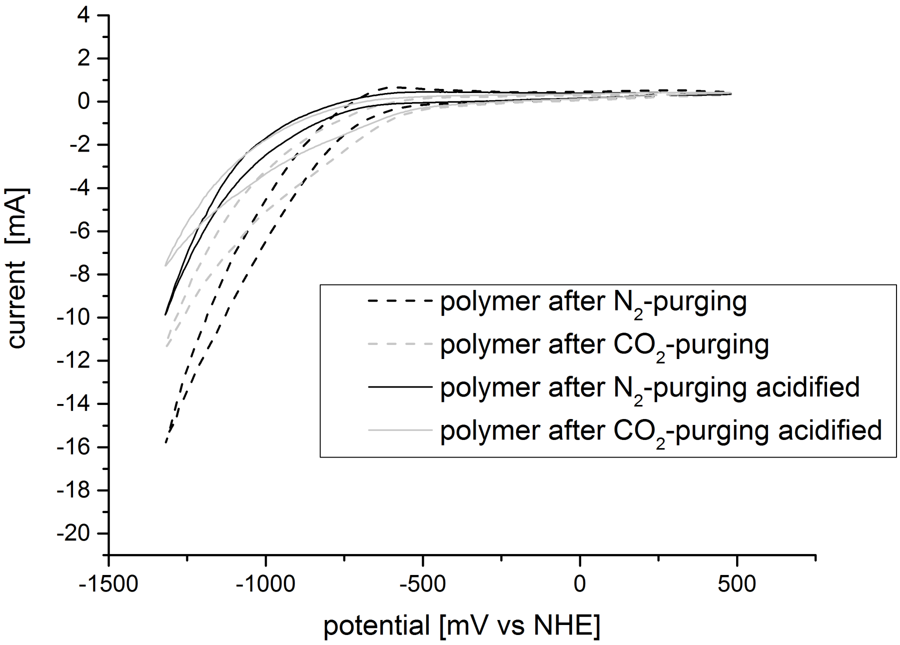

Figure 28: Cyclic voltammogram of polymeric-4-(3-Thienylheptyl)-pyridine-film measured with a scanrate of 50 mVs^{-1}. The polymerization is done in an one compartment-cell where a Pt-plate was used as working electrode. The counter electrode was also a Pt-plate and an Ag/AgCl-wire was used as quasi-reference electrode. 0.5 M KCl is used as electrolyte.

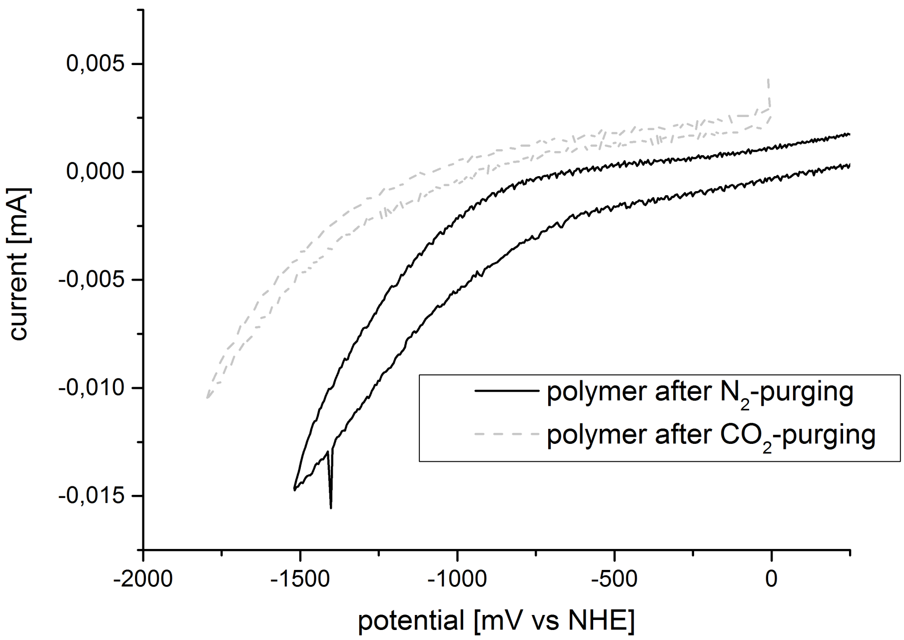

Figure 29: Cyclic voltammogram measured of the Re-complexed polymeric film with a scanrate of 10 mVs^{-1} in 0.1 M $TBAPF_6$ in propylen carbonate

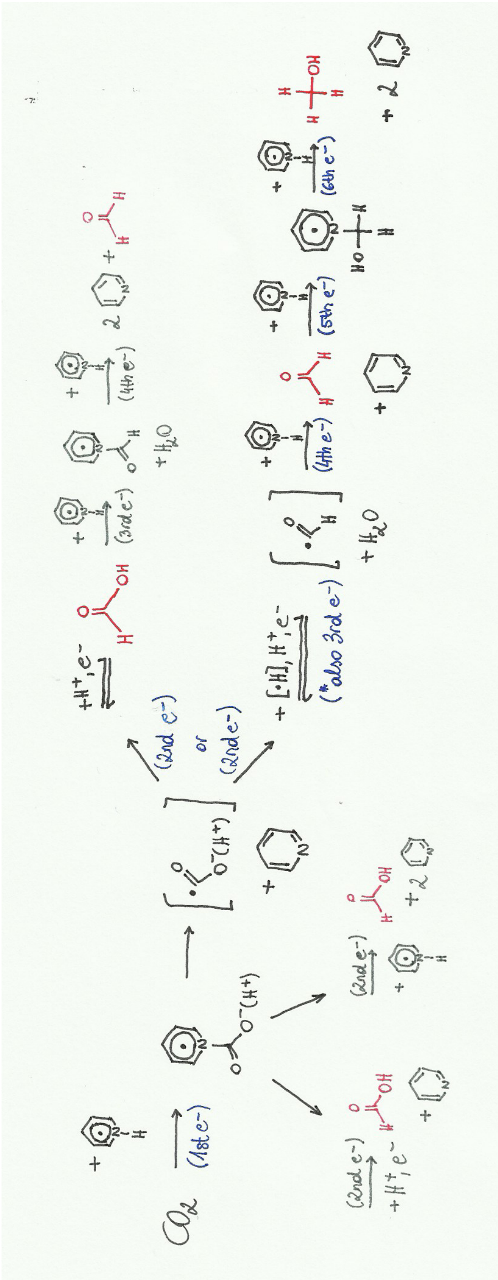

Figure 30: A proposed mechanism for CO_2-reduction with pyridinium to methanol
(E. B. Cole, P. S. Lakkaraju, D. M. Rampulla, A. J. Morris, E. Abelev and A. B. Bocarsly. *Using a One-Electron Shuttle for the Multielectron Reduction of* CO_2 *to Methanol: Kinetic, Mechanistic, and Structural Insights.*).

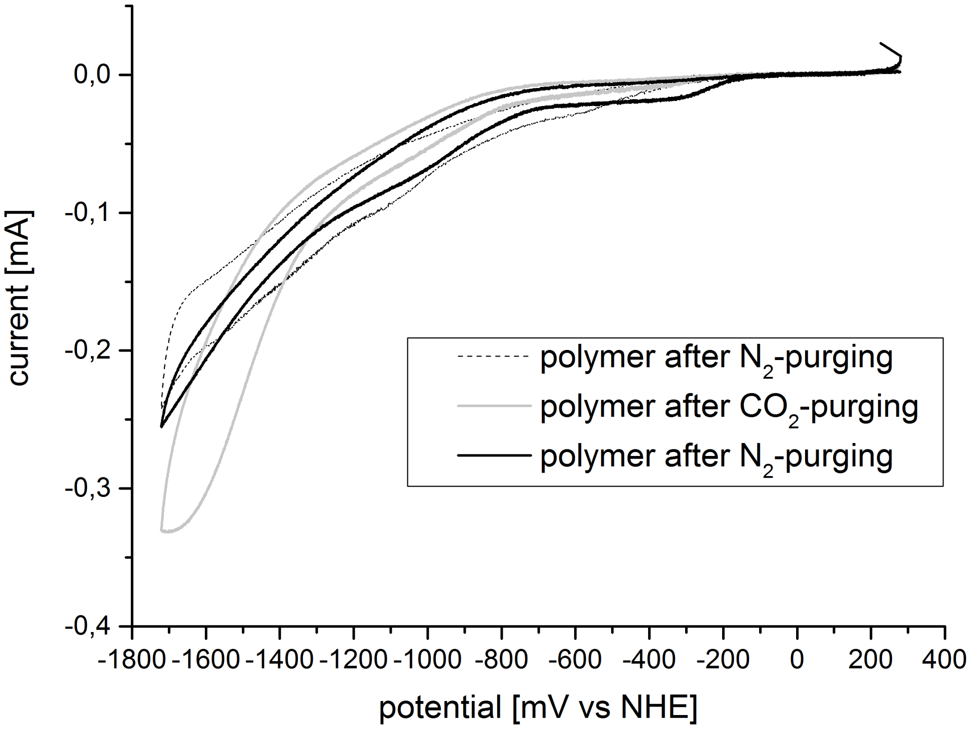

Figure 31: Characterization of [Re(4-Methyl-4′-(7-(3-thienyl)heptyl)-2,2′-bipyridinyl)$(CO)_3Cl$] film in 0.1 M $TBAPF_6$ in acetonitrile.

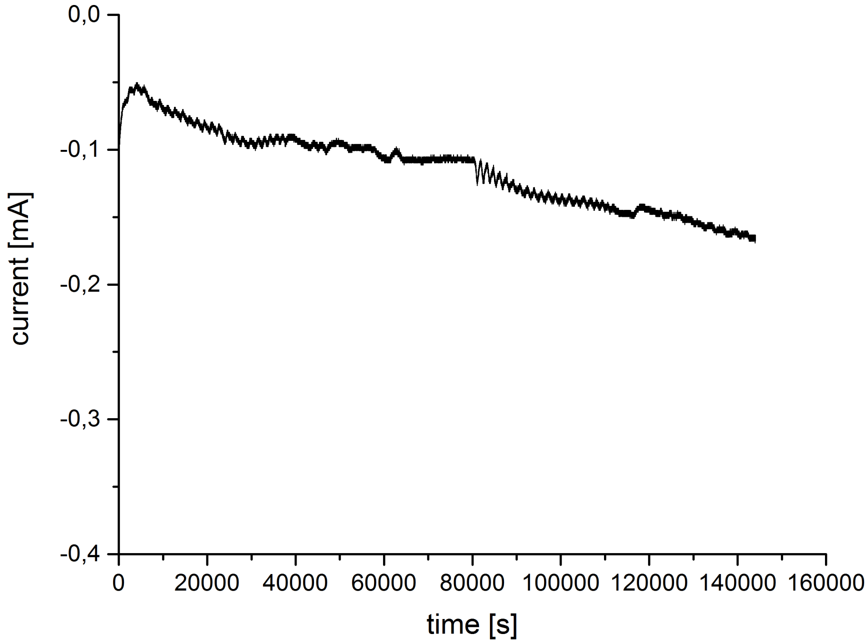

Figure 32: 40 hour electrolysis of pyridine functionalized poly(thiophene) in 0.1 M $TBAPF_6$ in acidified acetonitrile. Holdvalue at a potential of -1200 mV.

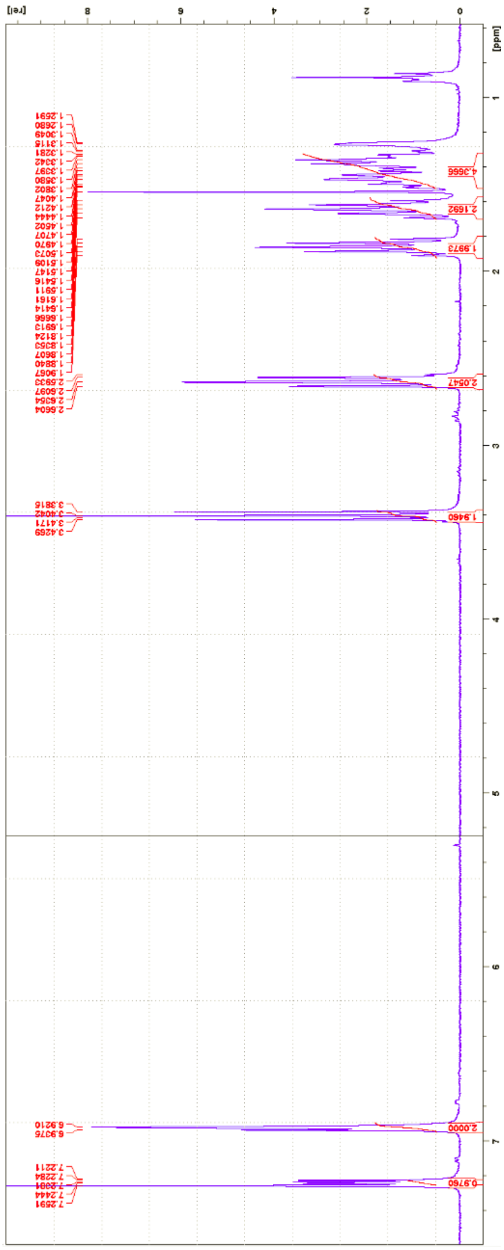

Figure 34: ^{1}H-NMR of 3-(6-Bromohexyl)-thiophene in $CDCl_3$

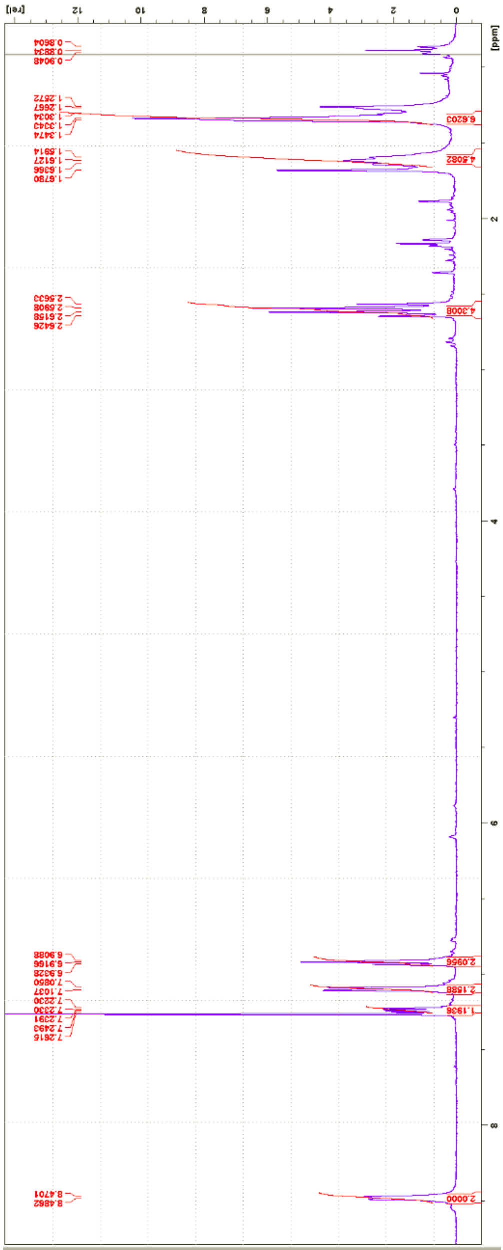

Figure 35: ^{1}H-NMR of 4-3-thienylheptyl-pyridine in $CDCl_3$

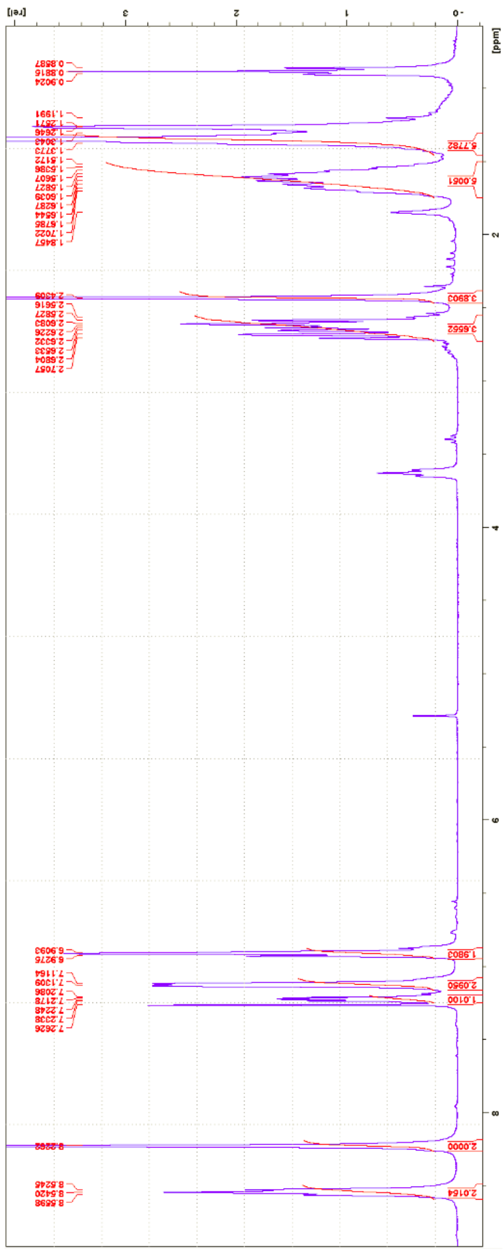

Figure 36: ^{1}H-NMR of 4′-3-thienylheptyl-2,2′-bipyridine in $CDCl_3$

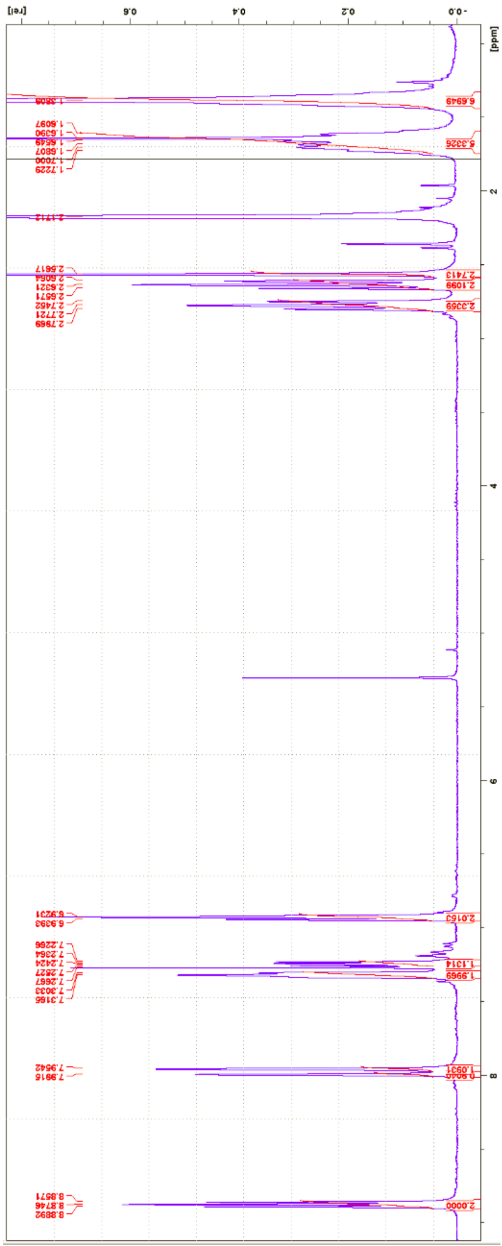

Figure 37: ^{1}H-NMR of 4-Methyl-4′-(3-thienylheptyl)-2,2′-bipyridinyl)-Re(CO)$_3$Cl

http://www.springer.com/978-3-658-10357-6

Pyridine-functionalized Polymeric Catalysts for
CO2-Reduction
Weichselbaumer, M.
2015, XVII, 60 p. 37 illus., Softcover
ISBN: 978-3-658-10357-6