The Determination of Effects of Reverse Bias on the Efficiency of Dye Solar Cells with the aid of Spectroscopic and Impedance studies

Dr LJ le Roux

CSIR-MSM

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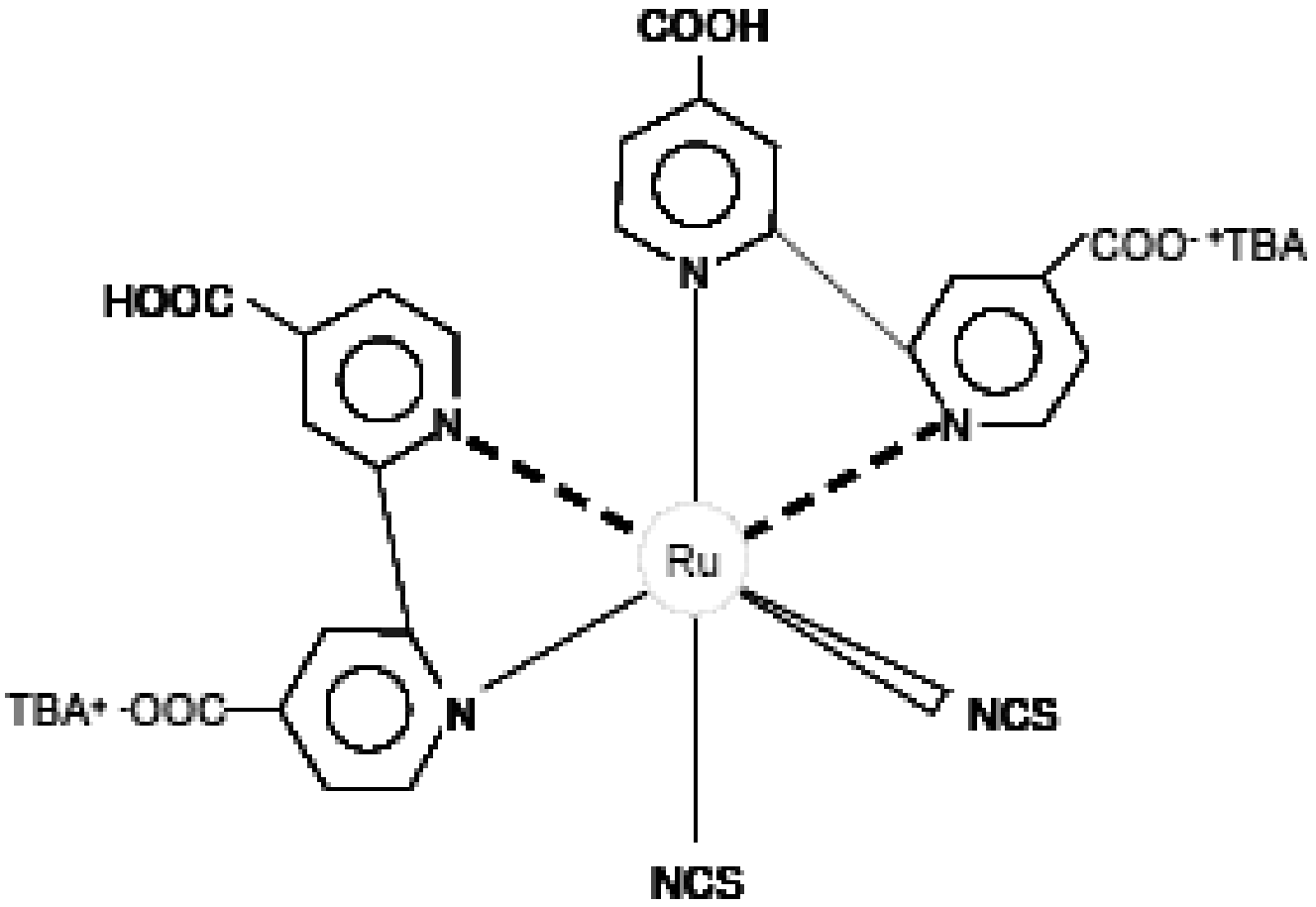
Abstract

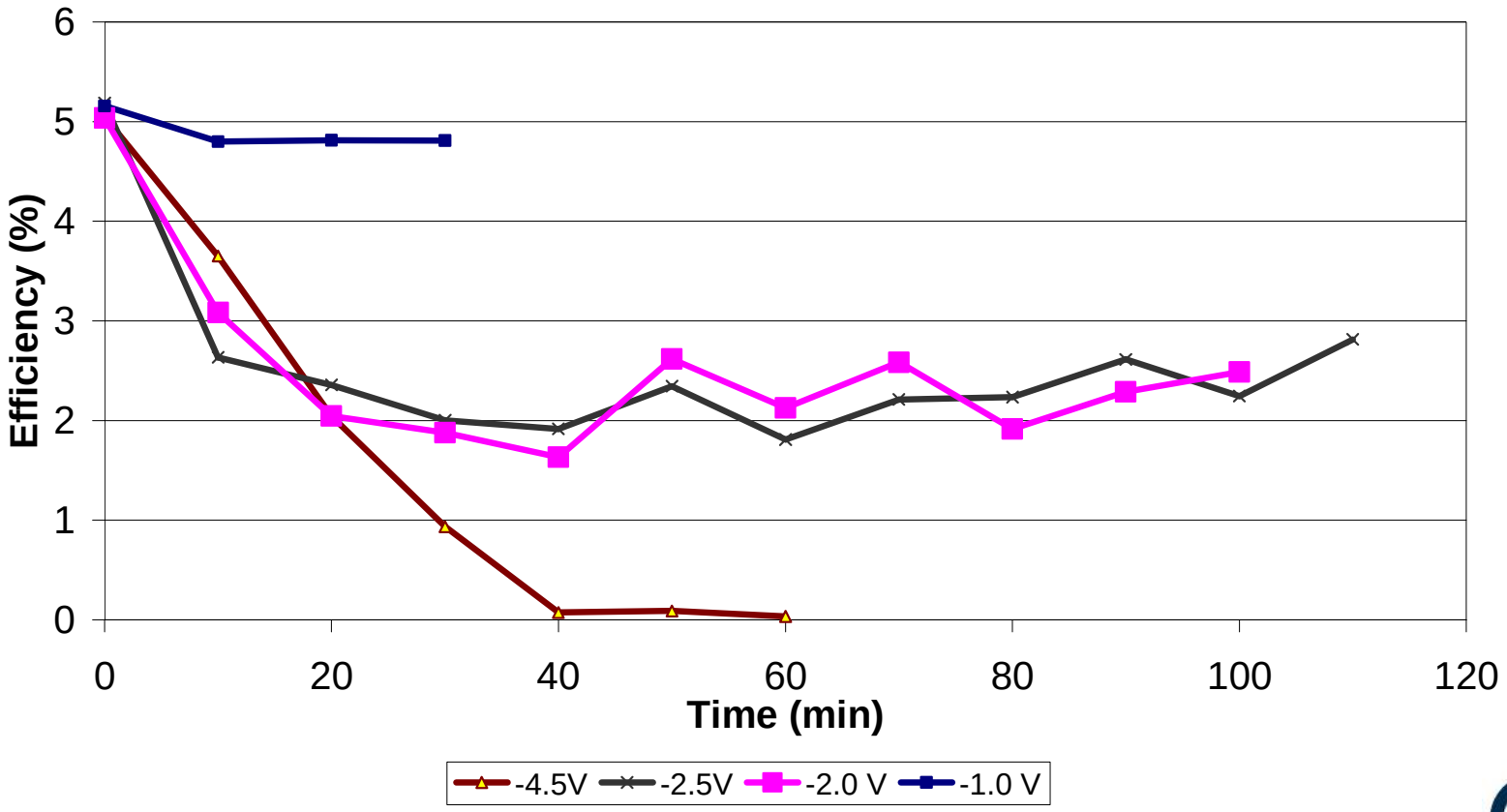
- The work that is presented here is focused on the results that were obtained during studies of the performance of the DSC under certain reverse bias conditions. When one cell in the series connection in a module is shaded, the current will pass this cell in reverse bias. Although the work is focussed on the chemical stability of the dye, various techniques were employed to determine the physical changes in the cell. This presentation shows how electrochemical and impedance measurements (Nyquist and Bode plots and IV curve data) can compliment spectroscopic measurements (FTIR, Raman, UV-vis) to characterise a dye solar cell.

Structure of the N719 Dye

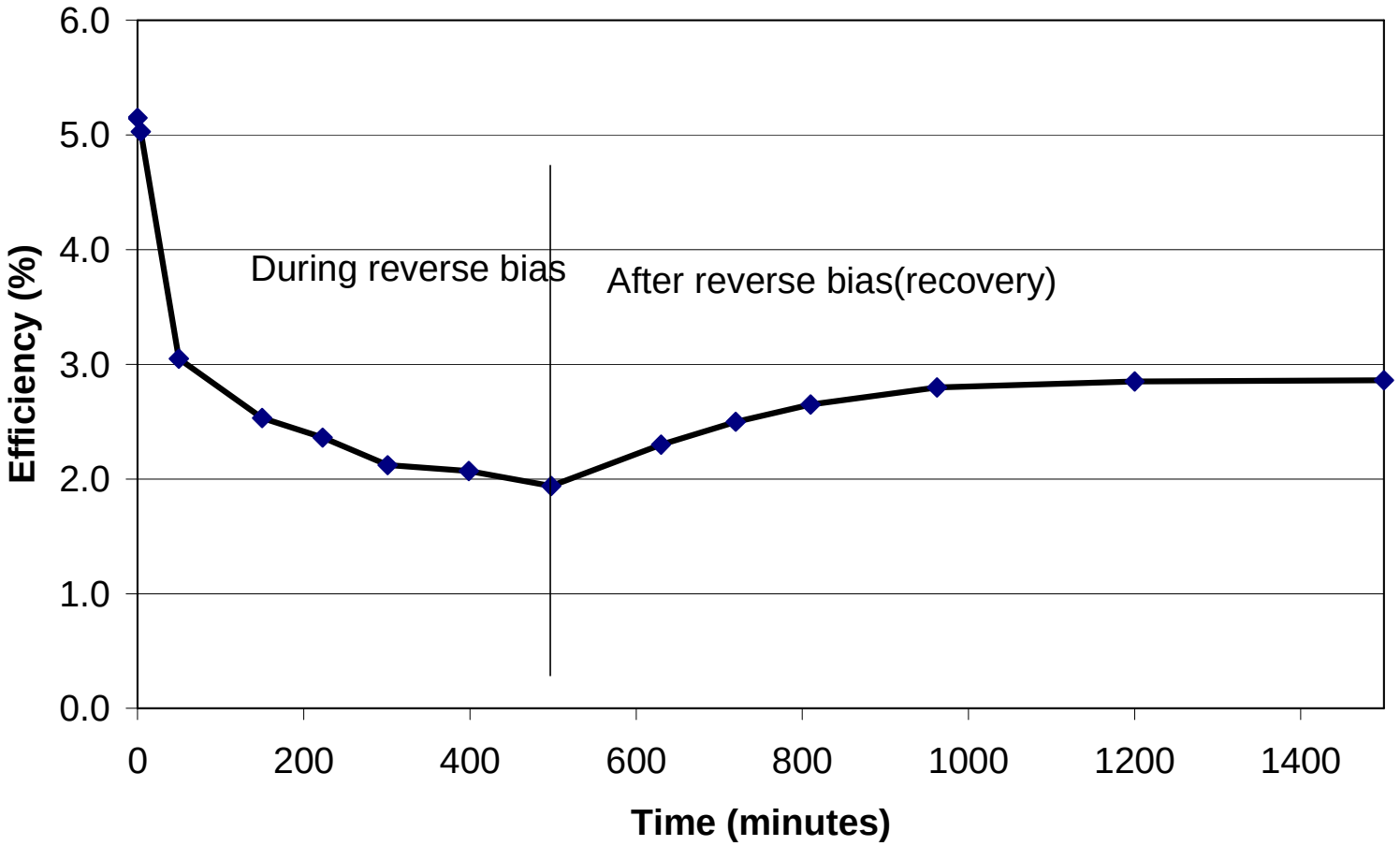


Electrochemical results

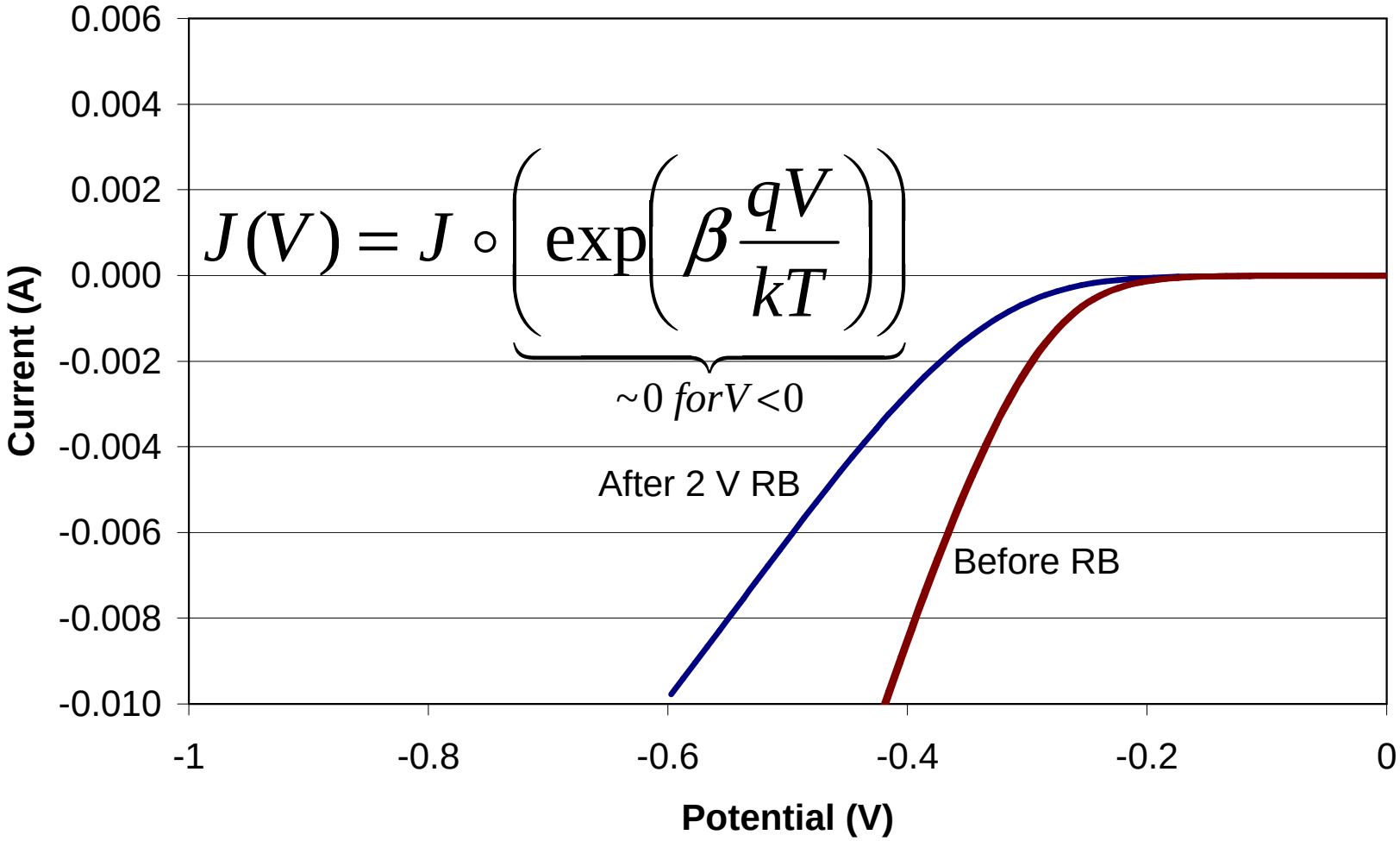
Efficiency vs. Time at Different RB Voltages



2V RB and Recovery



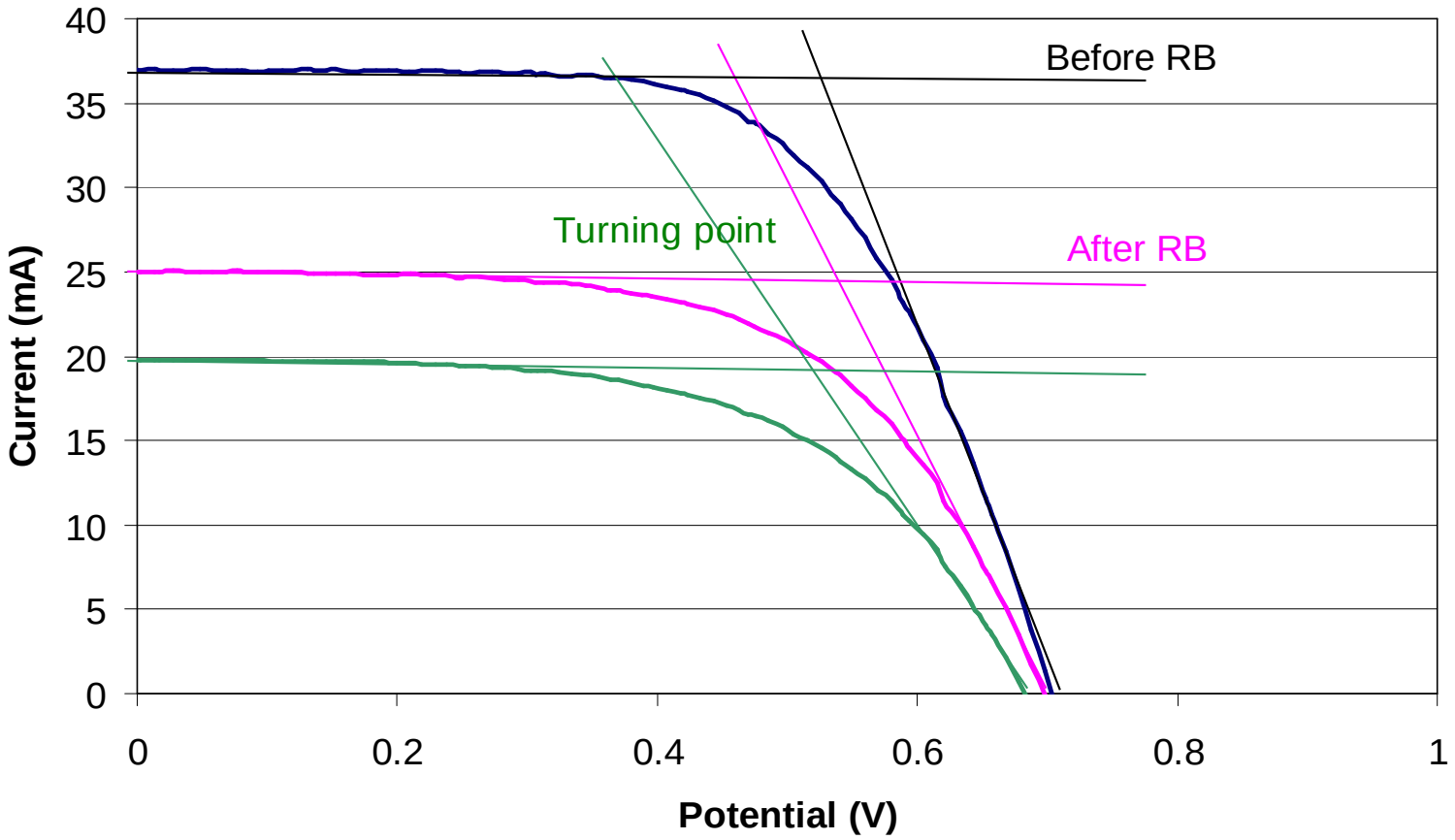
J_0 (rate of oxidation or reduction)



Before reverse bias: 7.2×10^{-11} A/cm^2

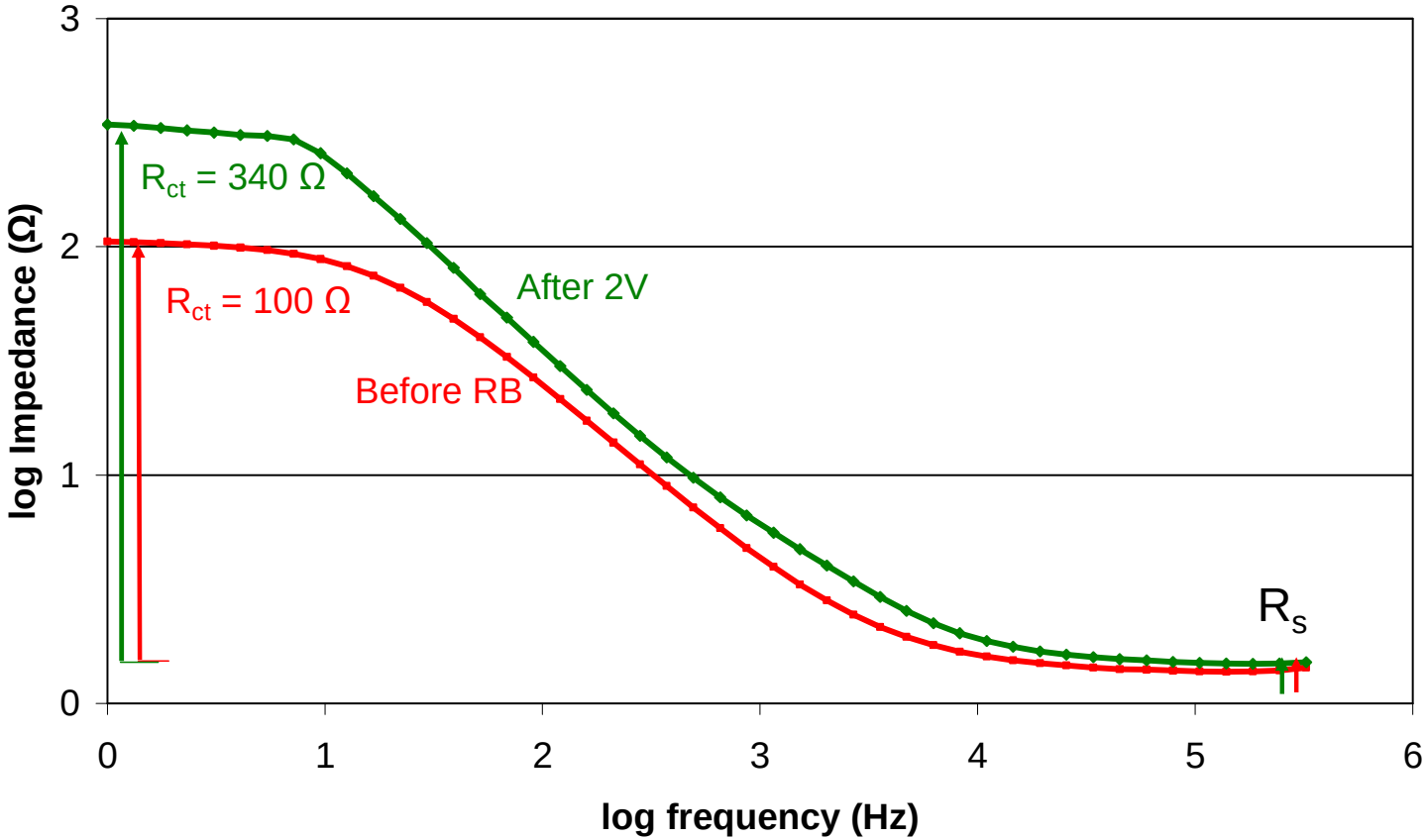
After reverse bias: 8.8×10^{-13} A/cm^2

IV Curves and Shunt/Series Resistance

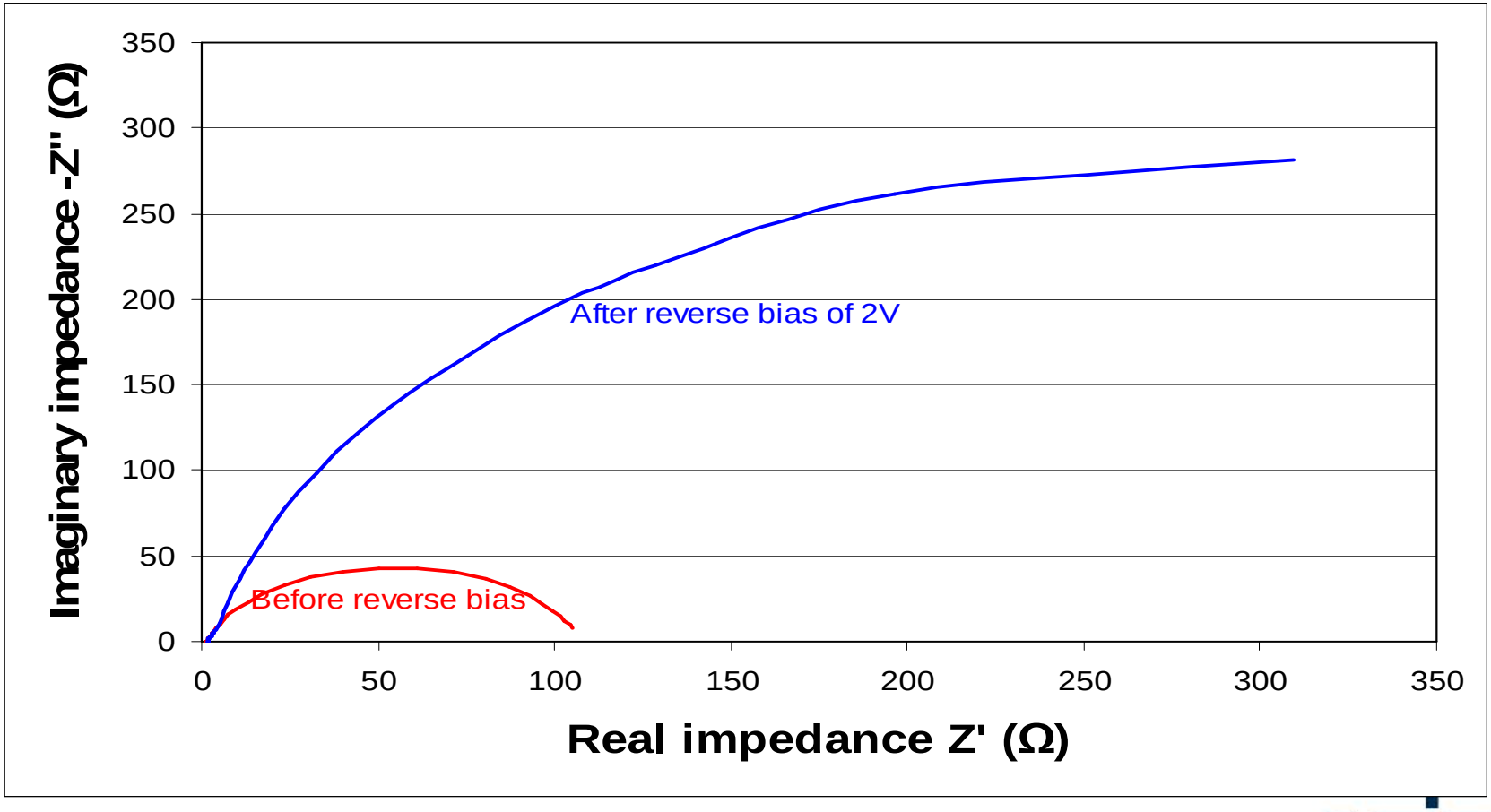


	R_{sh} (Ω)	R_s (Ω)
Before reverse bias	3324	4.3
Minimum efficiency (turning point)	2517	7.6
After recovery	3047	5.8

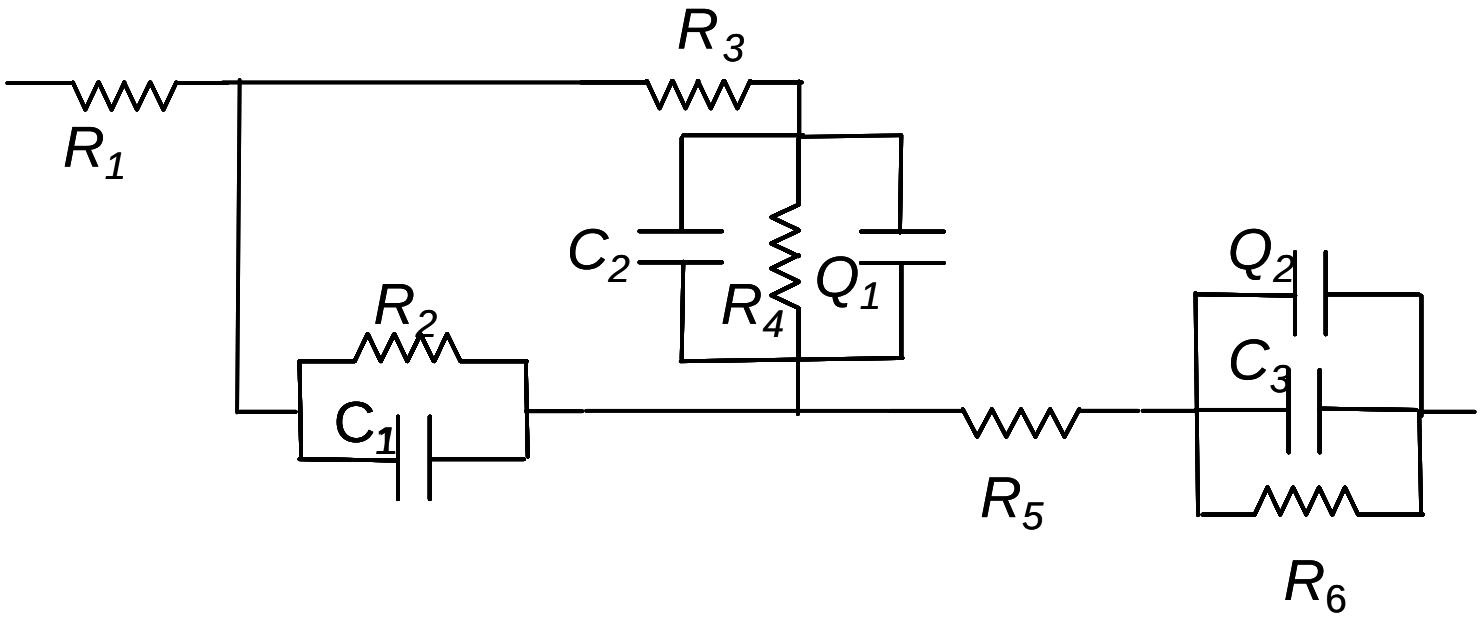
Bode Plots



Nyquist Plots



Equivalent Circuit

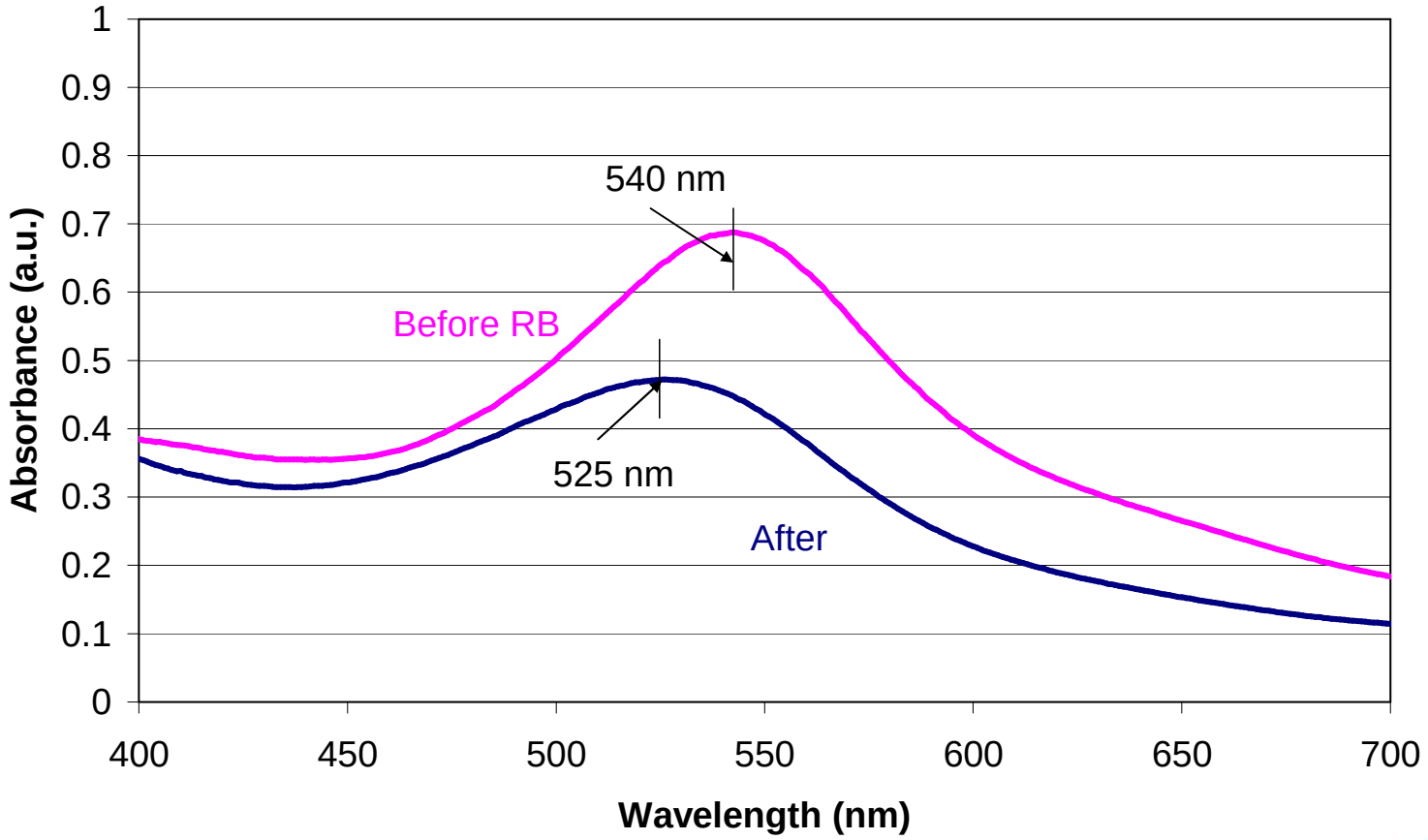


Equivalent Circuit and Nyquist Plot

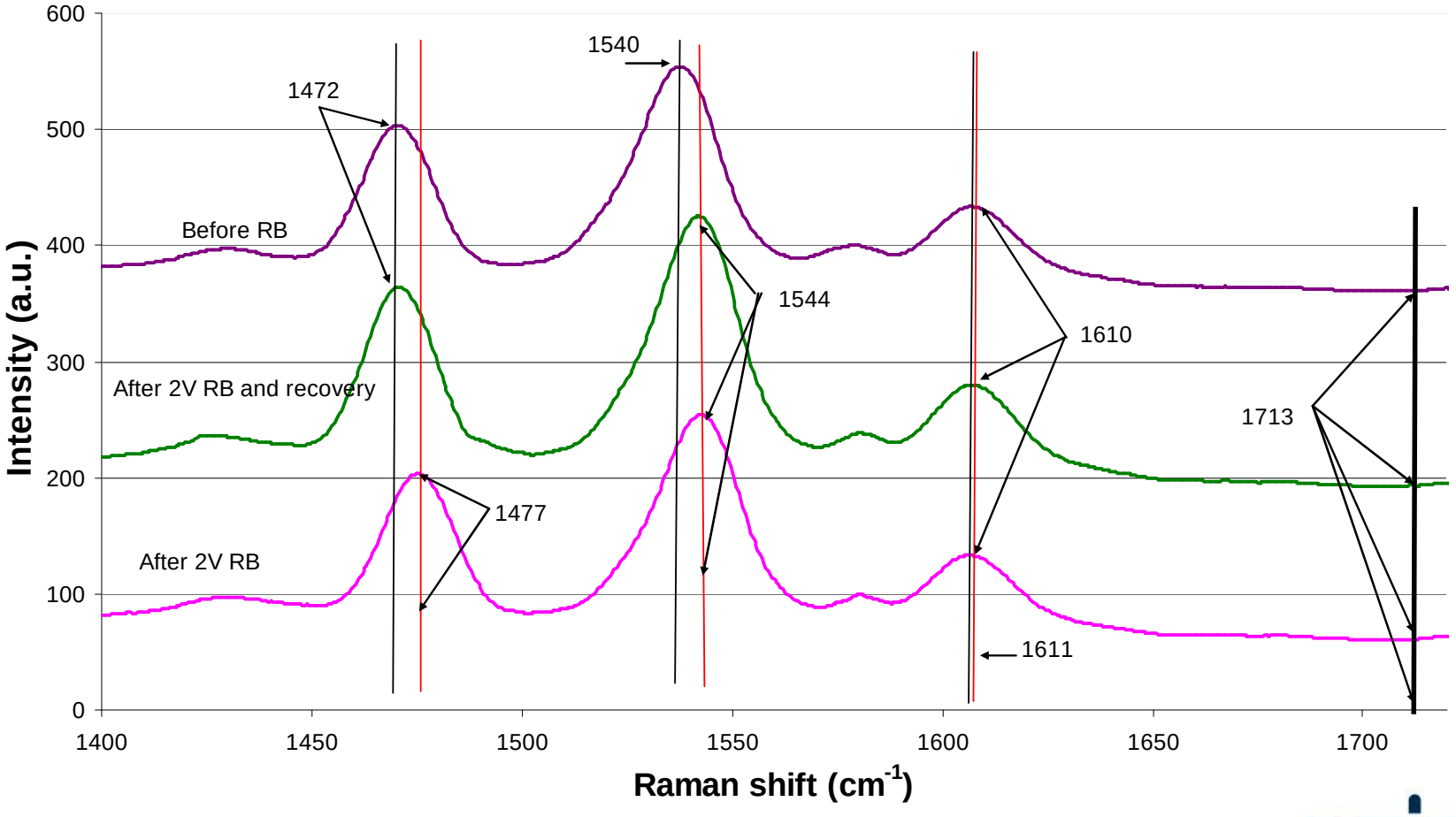
	Before reverse bias	After reverse bias of 2 V
R_1	4.73 Ω	4.73 Ω
C_1	1.00 pF	1.00 pF
R_2	12.8 mΩ	15.4 mΩ
R_3	4.73 Ω	4.73 Ω
C_2	22.8 µF	1.00 pF
R_4	46.8 Ω	146 Ω
Q_1	4.40×10^{-4}	7.98×10^{-4}
n_1	0.833	0.827
R_5	4.73 Ω	4.73 Ω
C_3	10.6 µF	1.00 pF
Q_2	4.46×10^{-4}	7.97×10^{-4}
n_2	0.834	0.829
R_6	61.3 Ω	208 Ω

Spectroscopic results

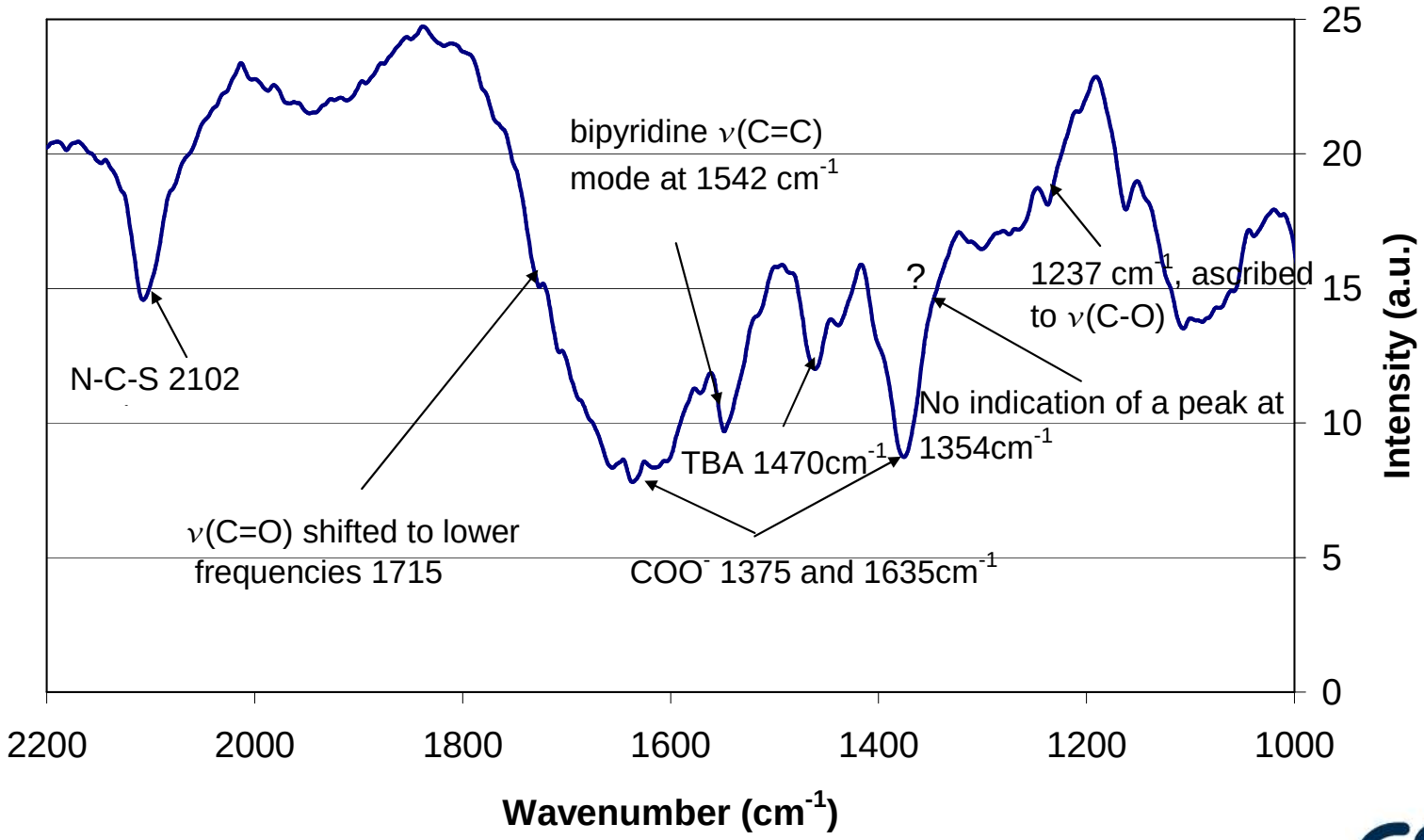
UV/Vis



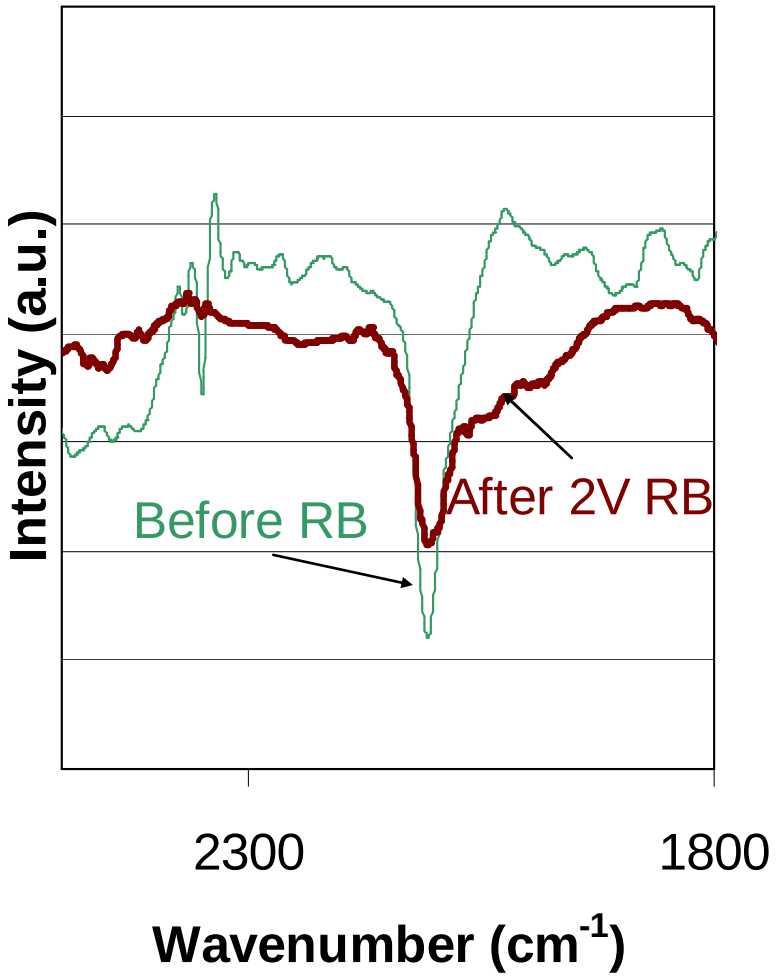
Raman



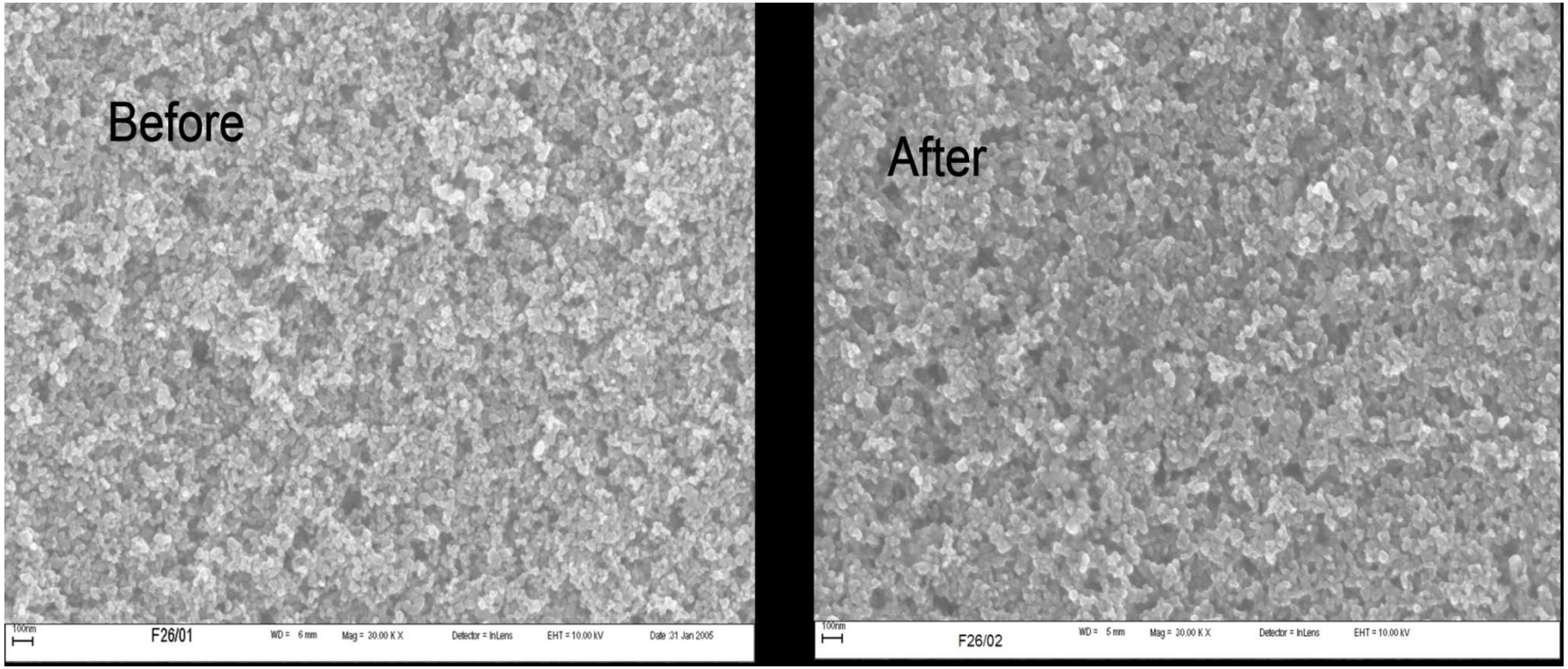
FTIR



FTIR (CN peak at 2100 cm^{-1})



SEM micrographs



Conclusions

- Butler Volmer (J_0 decreased; reaction rates decreased)
- IV curves (decrease in efficiency and R_{sh})
- Bode Plots (Increase in R_{ct} no change in R_s)
- Nyquist plots (Increase in impedance mostly at Pt interface and existence of CPE)
- UV/Vis (Blue shift indicates lower stability)
- Raman (No peak at 1713 – No broken bonds with TiO_2; Peak shift at 1540 indicates a change in the bipyridyl ligand)
- FTIR (No indication of free C=O – no broken bonds with TiO_2; Decrease in CN peak intensity
- SEM (No change in morphology)

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