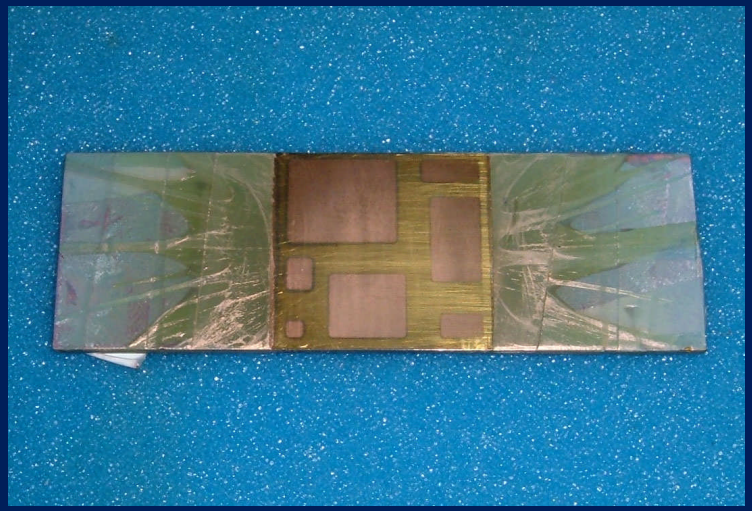
Thin-film Polypropylene Capacitors



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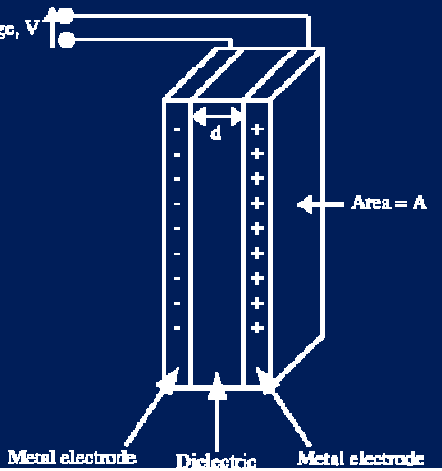
The Capacitor

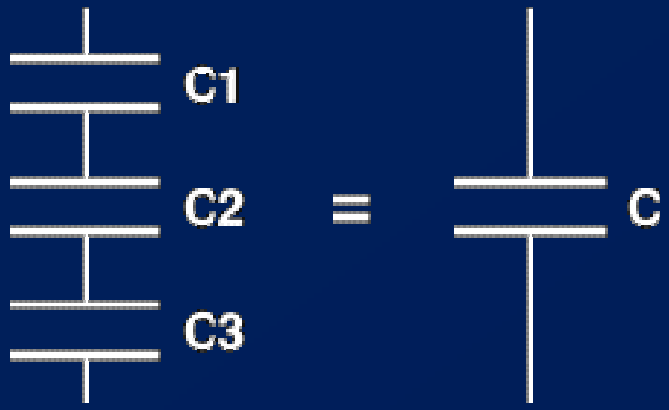
- Consist of a dielectric material sandwiched between two metal electrodes
- Several types of capacitors:
  - -Electrolytic
  - -Ceramic
  - -Electrochemical (supercapacitors)
- Properties of a parallel-plate capacitor are governed by:

$C=\varepsilon*A/d$, $E=1/2*C*V^2$, $Q=V*C$



Series Capacitance

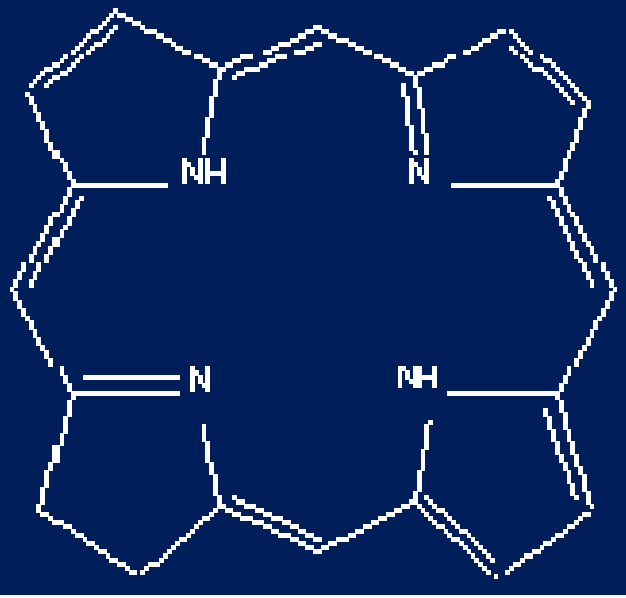
When connected in series *n* number of capacitors have an equivalent capacitance of:



$$1/C_1 + 1/C_2 + 1/C_3 = 1/C_{equiv}$$

Porphyrins

- Natural pigments which consist of four pyrrole subunits linked via four methine bridges
- The properties of free base porphyrins can be manipulated by adding metal ions to the center of their structures



Potential Applications

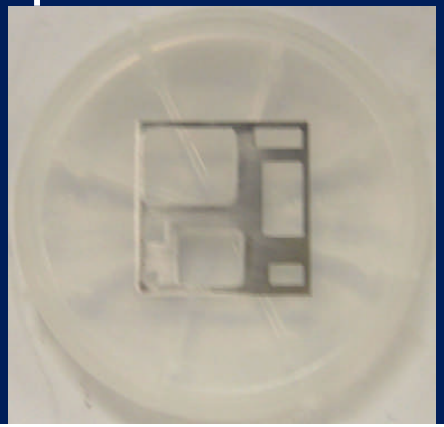
- Electric vehicles
- Medical instrumentation
- Aviation and aerospace vehicles
- Military
- High voltage industrial processes

The Dielectric Compound

- An organic polymer called polypropylene
- Relatively cheap to produce
- Breakdowns at a high voltage of 640 V/μm
- Can operate at high temperatures
- Highly Polarizable
- Commercially Available

Testing Process

- Measurement of the capacitance of polypropylene dielectrics
- Thickness was an important variable as it is indirectly proportional to capacitance
    - $C=\epsilon*A/d$
- A film of doped polypropylene was spin-cast on a gold-plated microscope slide
- A thin layer of gold was vapor-deposited onto the film to complete the capacitor

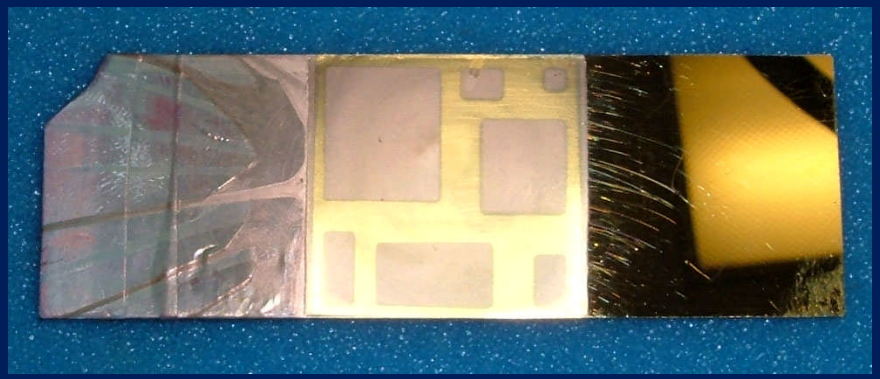


Problems & Solutions

- Increasing the capacitance of polypropylene
- Polypropylene was doped with various porphyrins to see if such additives increased capacitance
- The polypropylene film was initially too thin, making the capacitance too large for the capacitance bridge

$$C=\varepsilon*A/d$$

- As a result three layers had to be deposited in order to increase thickness

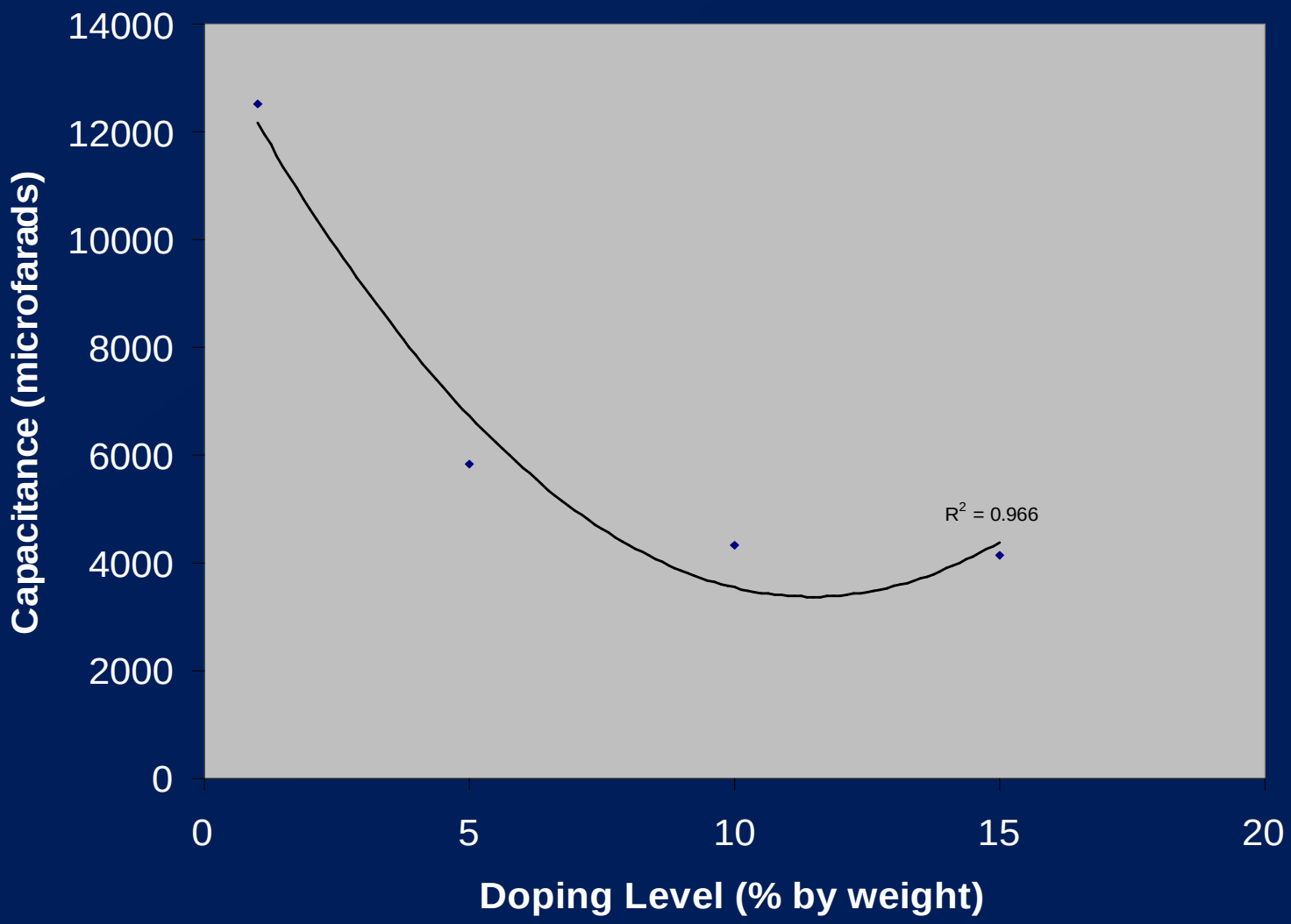


Problems & Solutions

- Accurate measurement of the film thickness was also difficult
- An ellipsometer was used but it could not evaluate the film’s thickness with enough precision

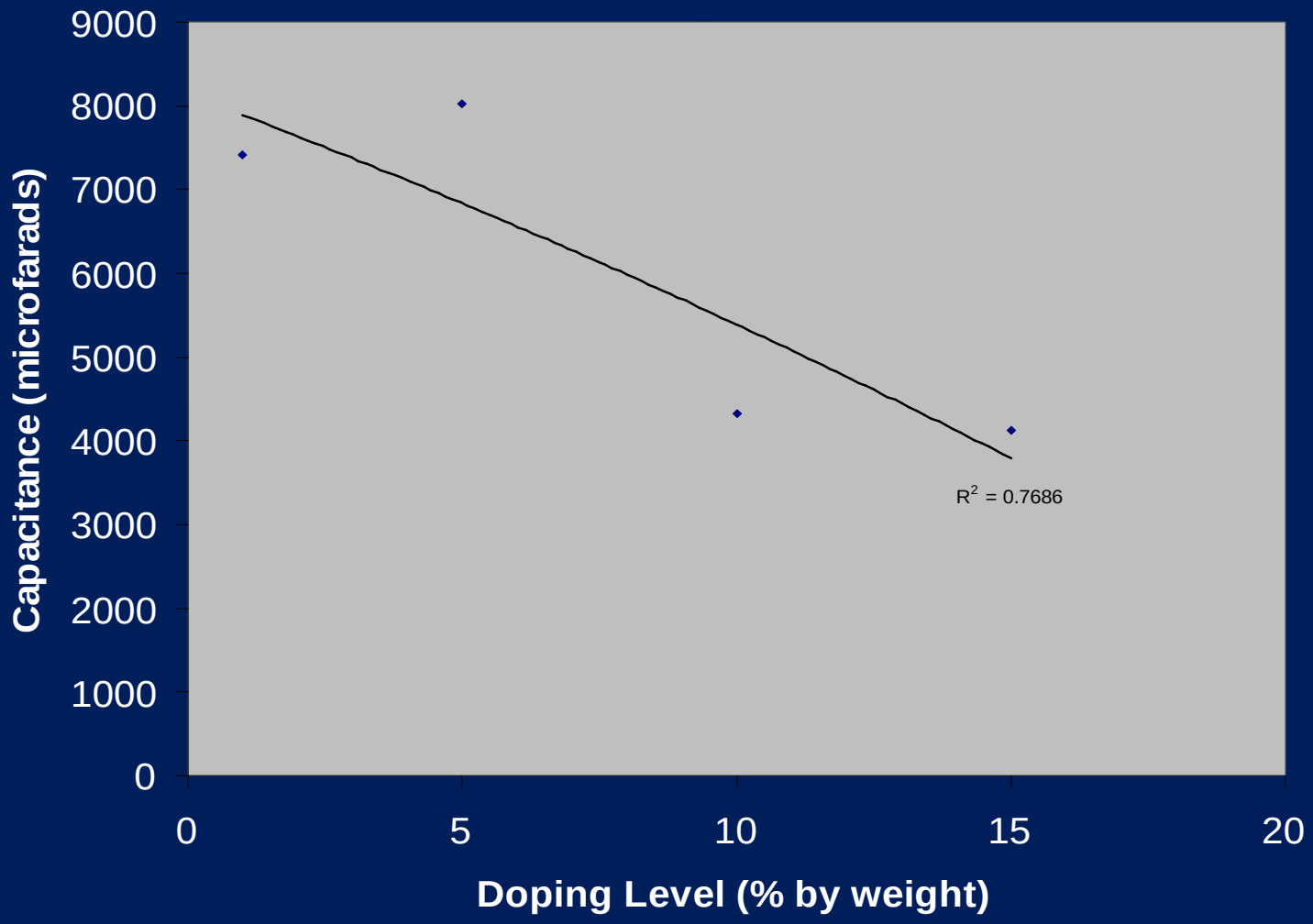
Final Results

.03516 cm. ^2 -100 Hz



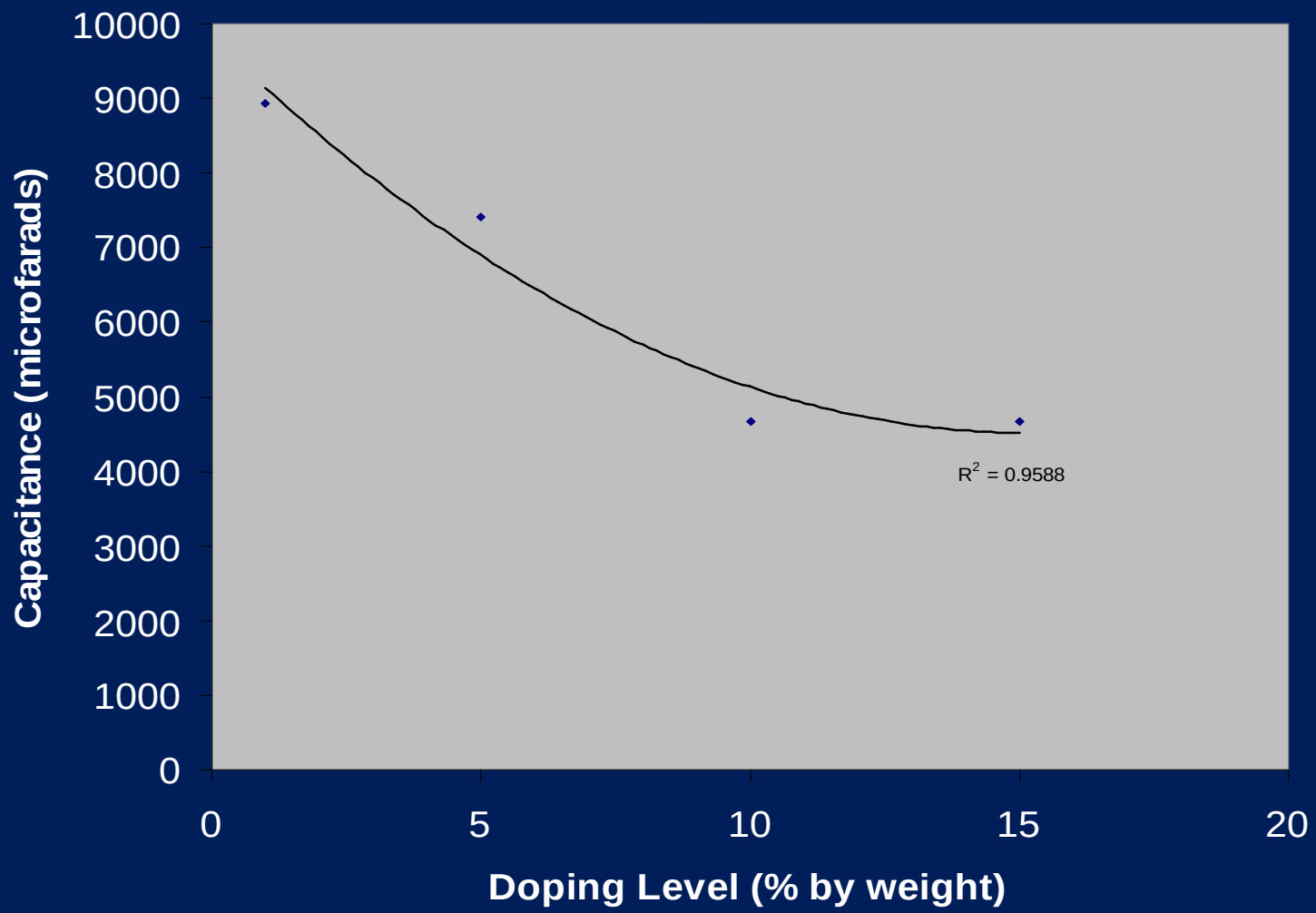
Final Results

.1057 cm. ^2 -100 Hz

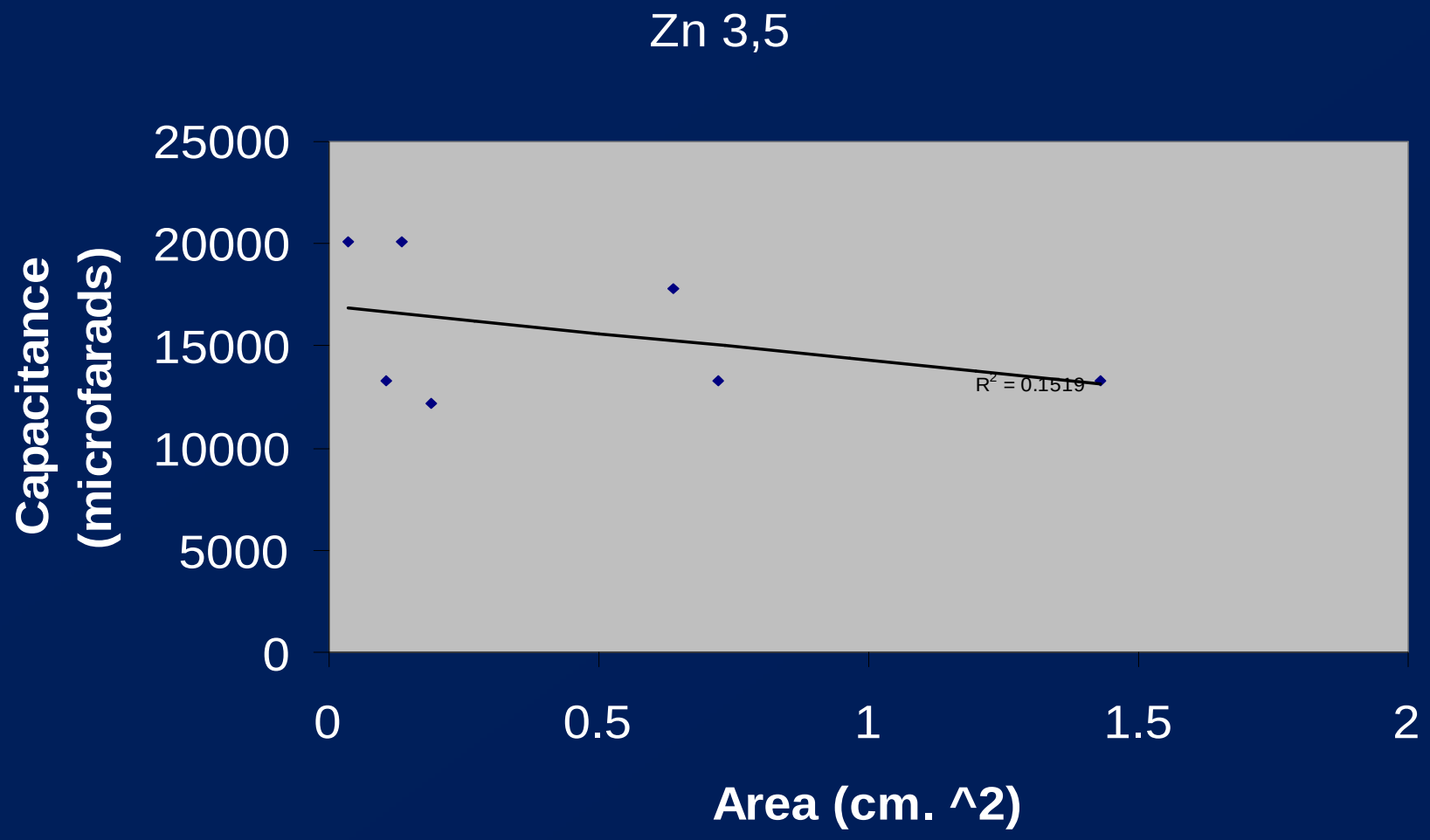


Final Results

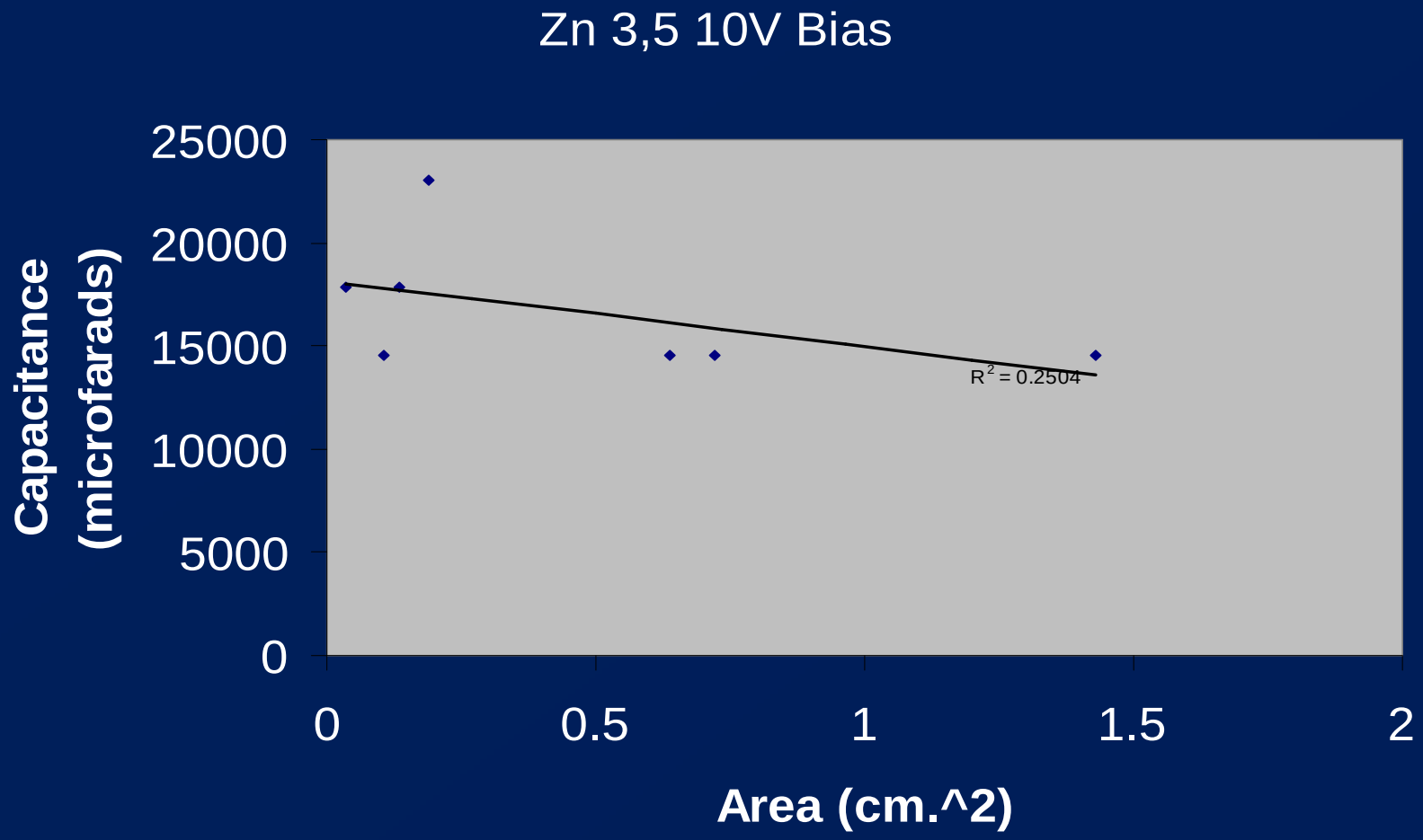
1.43 cm. ^2 -100 Hz



Initial Results



Initial Results



Conclusion

- Porphyrins have been found to be an effective additive for increasing the capacitance of polypropylene and with further research could definitely be placed into future applications

Acknowledgements

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