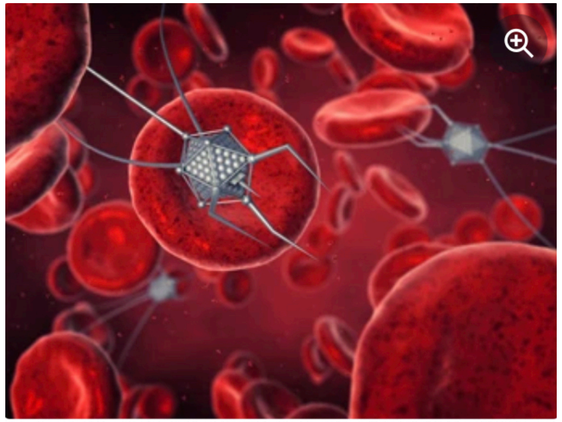
Going to the study of processing and properties of melanin and melanin composite materials — a second chapter towards the depiction of the ambipolar-states of scientific events

DEPICTING FOR THE BENEFIT OF

NANOTECHNOLOGY



BIOTECHNOLOGY

PLANETARY SCIENCES

Johns Hopkins University
Bloomberg School of Public Health
Department of Molecular Microbiology and Immunology

Jesús M. García-Figueroa
Supervised by: Radamés JB Cordero

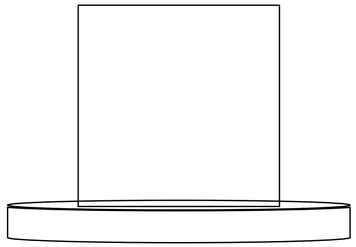
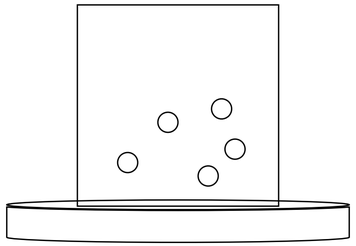
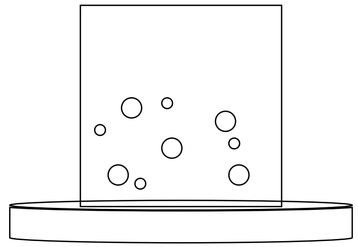
Arturo-Casadevall's Group Meeting
Wednesday, June 29, 2022
ZOOM Meeting | 11:00 AM EDT

AGENDA

1. Studying the Ambipolar States of Scientific Events
2. Accomplishment Studying the Ambipolar-State of the Manufacture of Diamond like-Composition Films via Electron Cyclotron Resonance – Microwave – Chemical Vapor Deposition (ECR-MW-CVD) Method
3. Current Status on Understanding the properties and enhancing the processing of melanin and melanin composite materials through the depiction of the ambipolar states of multiple scientific events

The ambipolar state is the condition created by the coexistence of species with opposite characteristics (e.g., electrons vs. positively charged ions)

TYPES OF NATURE OF THE AMBIPOLAR-STATE

INTRINSIC	FORCED	ALTERED
		
Water at 25ºC 1 atm	Water at 100ºC 1 atm	10 Molal of Sucrose Aqueous Solution at 105ºC 1 atm

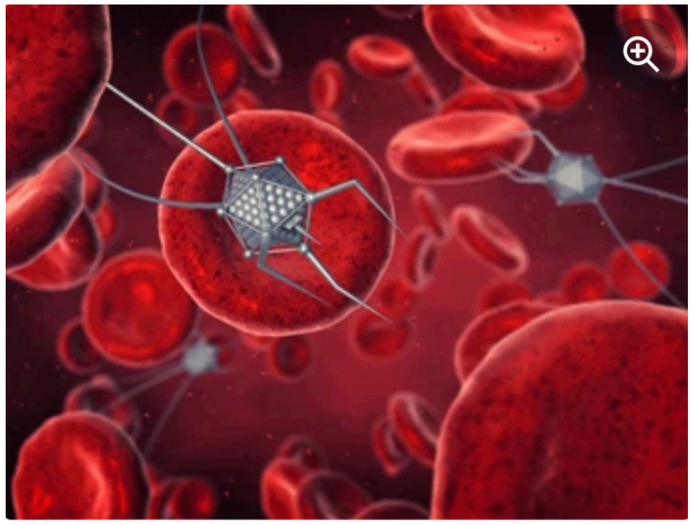
○ Vapor Bubbles ○ Sucrose

Understanding the ambipolar state of scientific events would help to explain events like this from a centric and empiric approach

Studying the ambipolar state of scientific events and benefiting public health

NANOTECHNOLOGY

- Scaling Up the Manufacturing of Nanomaterials
- Making biocompatible and safer nanomaterials
- Improving the cost-effectiveness of manufacturing novel nanomaterials



BIOTECHNOLOGY

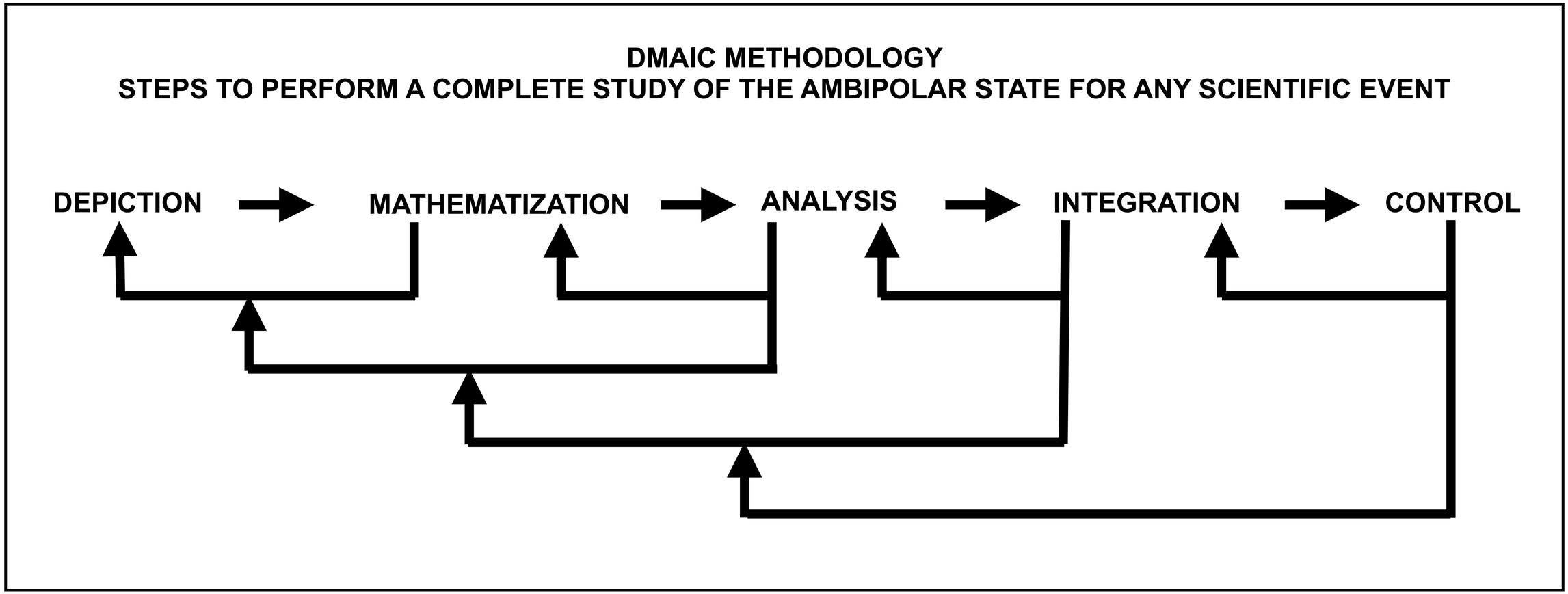
- Improving Clinical Trials
- Enhancing Stem Cell Research
- Defending us against bioterrorism

PLANETARY SCIENCES

- Making Humans Adaptable to Climate Change
- Restoring Earth's Ecosystem
- Cleaning our pollutants at the atomic level

We need to expand our current knowledge of the ambipolar state of scientific events to tackle these and other challenges anyhow, anywhere, and in remarkable ways

The ambipolar state of scientific events can be studied using the DMAIC methodology

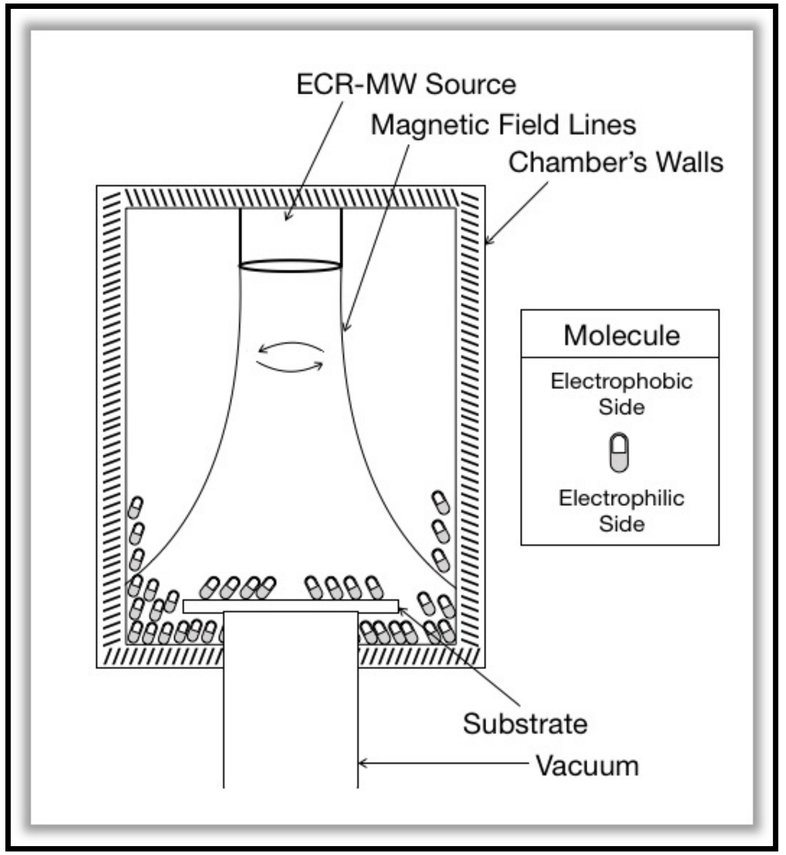


Doing depictions of ambipolar-states of scientific events alone would allow humanity to make any material, anyhow, anywhere; nonetheless, depictions should be done for more scientific events.

The first depiction of ambipolar-state alone qualified the via electron cyclotron resonance – microwave – chemical vapor deposition (ECR-MW-CVD) method to manufacture diamond-like-composition hydrocarbon films for laser fusion experiments at < 200ºC

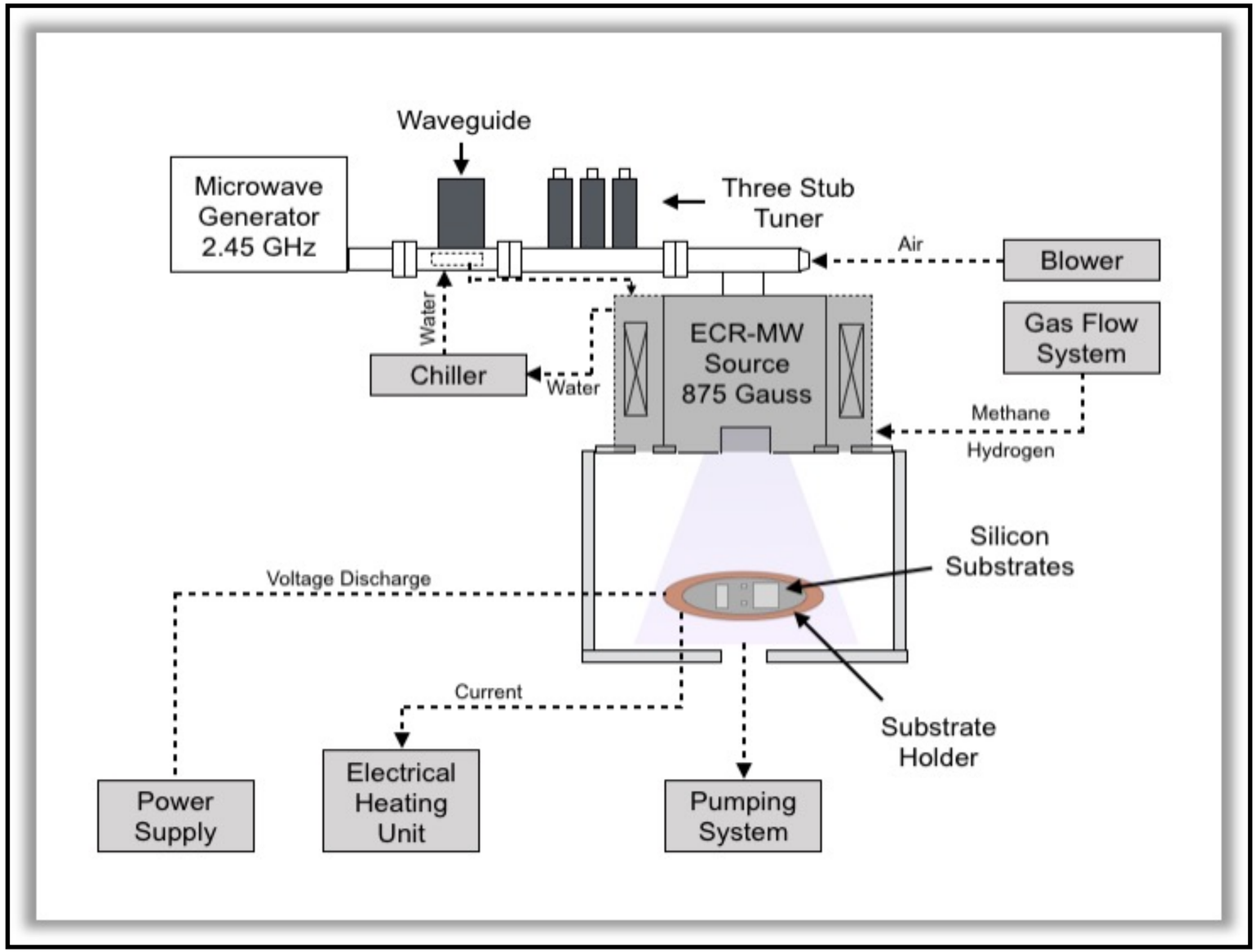
We did not know

- **If and how the method can vapor deposit diamond-like-composition films**
- **If and how the method could be incorporated into the current process for making capsules' shells for laser fusion experiments**
- **How the method works for depositing specialty materials (e.g., aluminum carbide, boron nitride) at ≤ 200ºC**



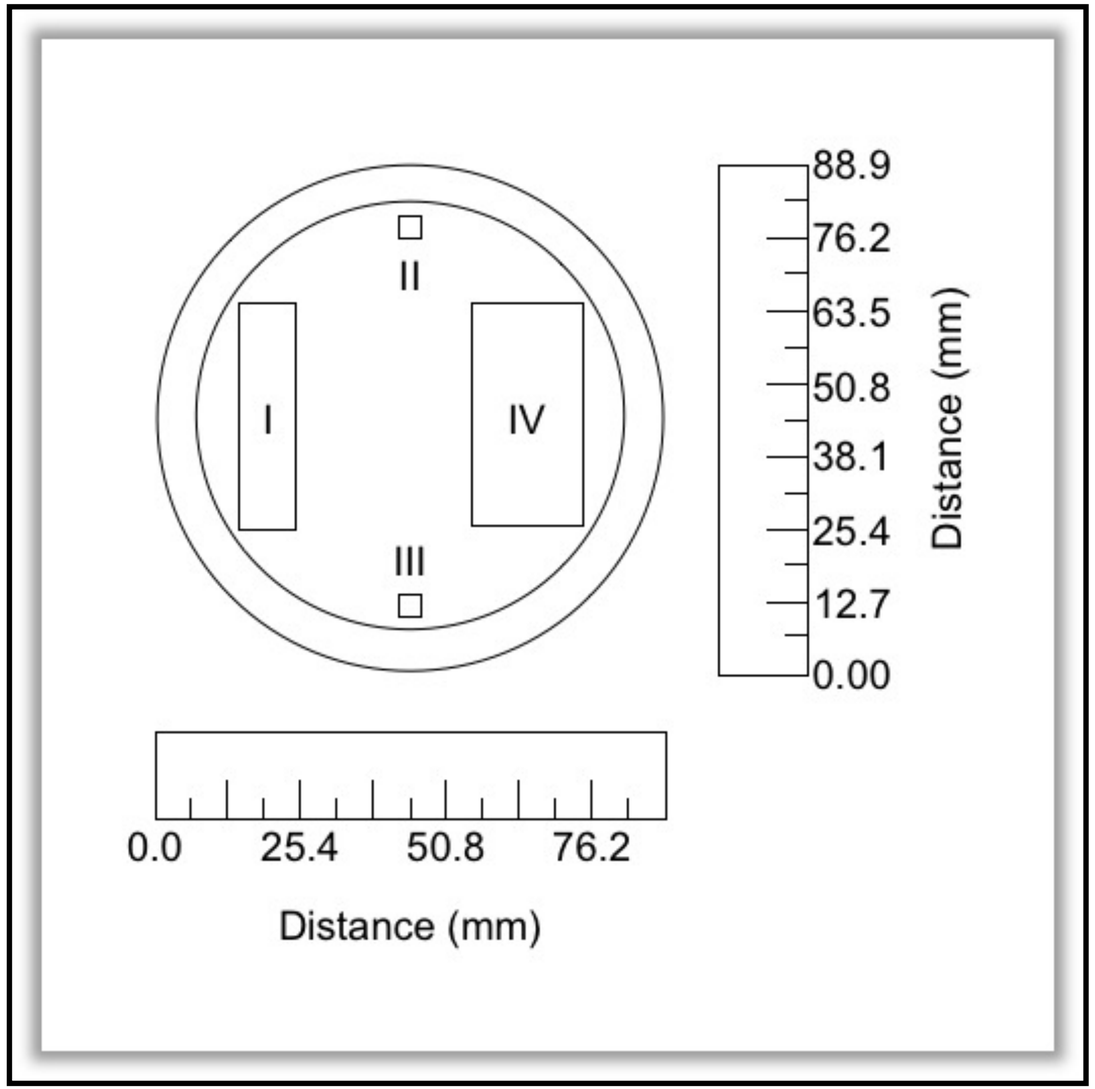
The depiction alone proved that an ECR-MW-CVD method could make diamond-like-composition films as a one-step process at < 200ºC and in a controlled way

One-line Diagram of the ECR-MW-CVD System's Assembly Used to Depict the ECR-MW-CVD Method's Ambipolar-State.



Deposition of Diamond like-Composition Hydrocarbon Films

Position of 0.38 mm-thick silicon substrates [1,0,0] on the substrate's holder



Conditions used to Deposit the Films

Deposition Parameter	Range / Value
Time	18m – 1d
ECR-MW Power	100 – 650 W
ECR-MW Resistance	1.58 – 1.69 Ohms
Substrate Temperature	30 – 200ºC
Direct Voltage Discharge	-50, 0, and +50 VDC
Pressure	3 – 7 Pa
ECR-MW Reflected Power	0 – 15 W
Base Pressure	1.3 x 10^{-3} Pa

Substrate

I >> Thickness, Microstucture, Coating Uniformity, Refractive Index, Toughness

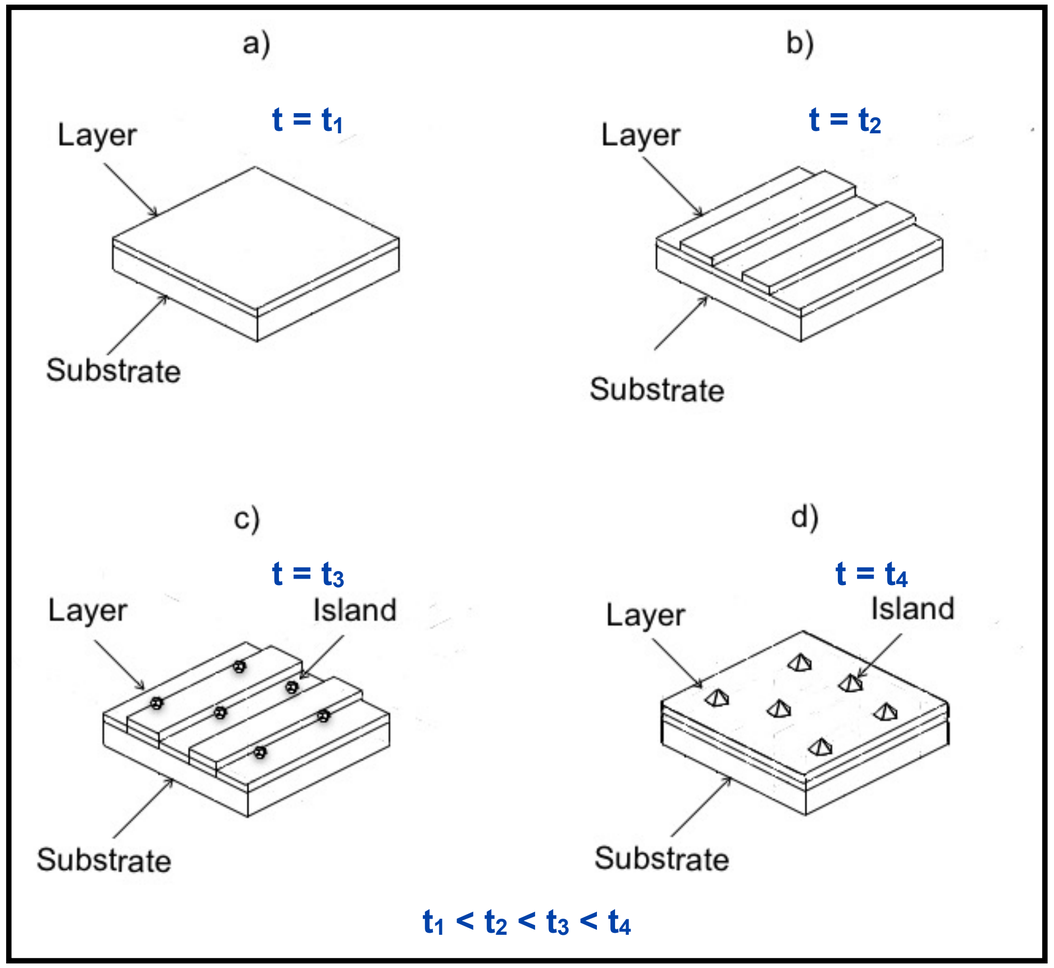
II >> Thickness, Microstructure, Coating Uniformity, Density

III >> Density

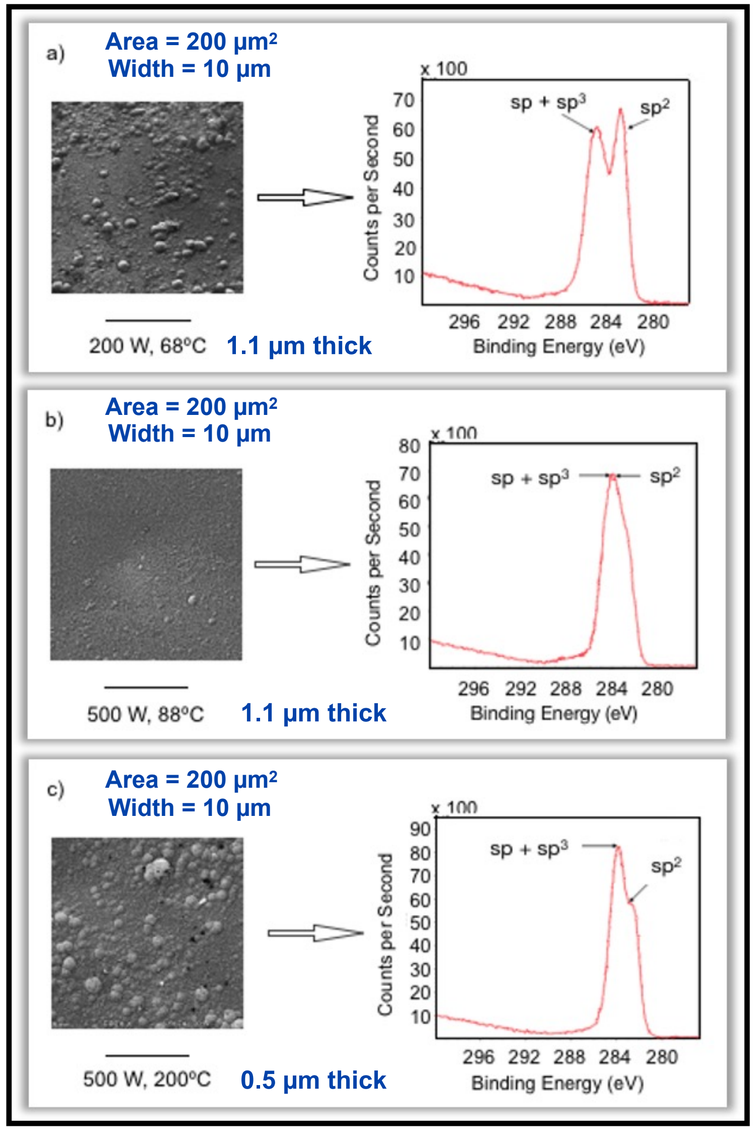
IV >> Color, Translucency, Refractive Index, Surface Chemistry

Microstructure and Surface Chemistry of Films Grown Settling the ECR-MW Source at Different Powers on Thermally Heated Substrates Showed that the ECR-MW-CVD Method's Ambipolar-State is Transient, Discrete and Susceptible, and Thus, Discriminant.

Films Growing According to the Stranski-Krastanov Growth Model

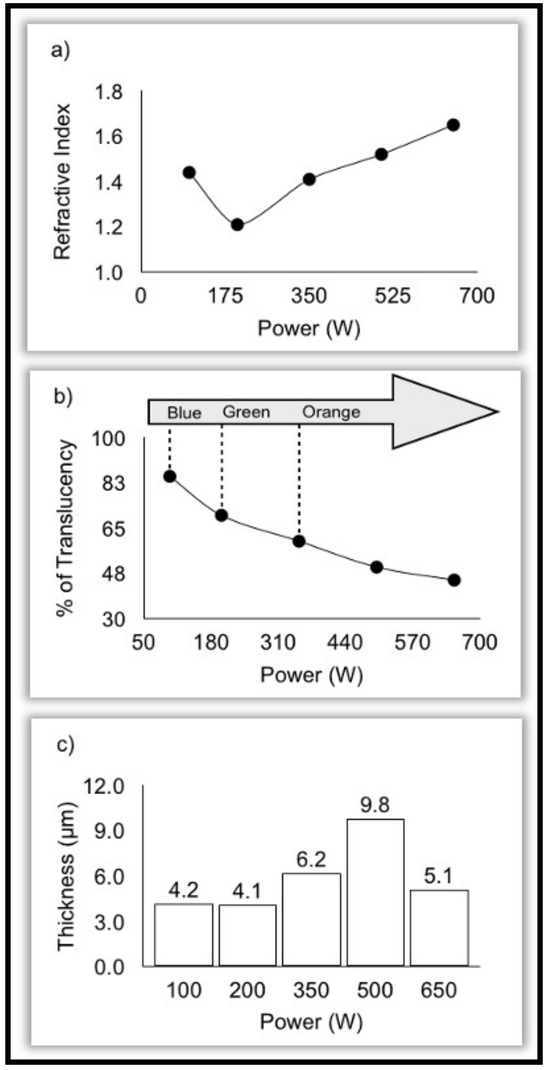


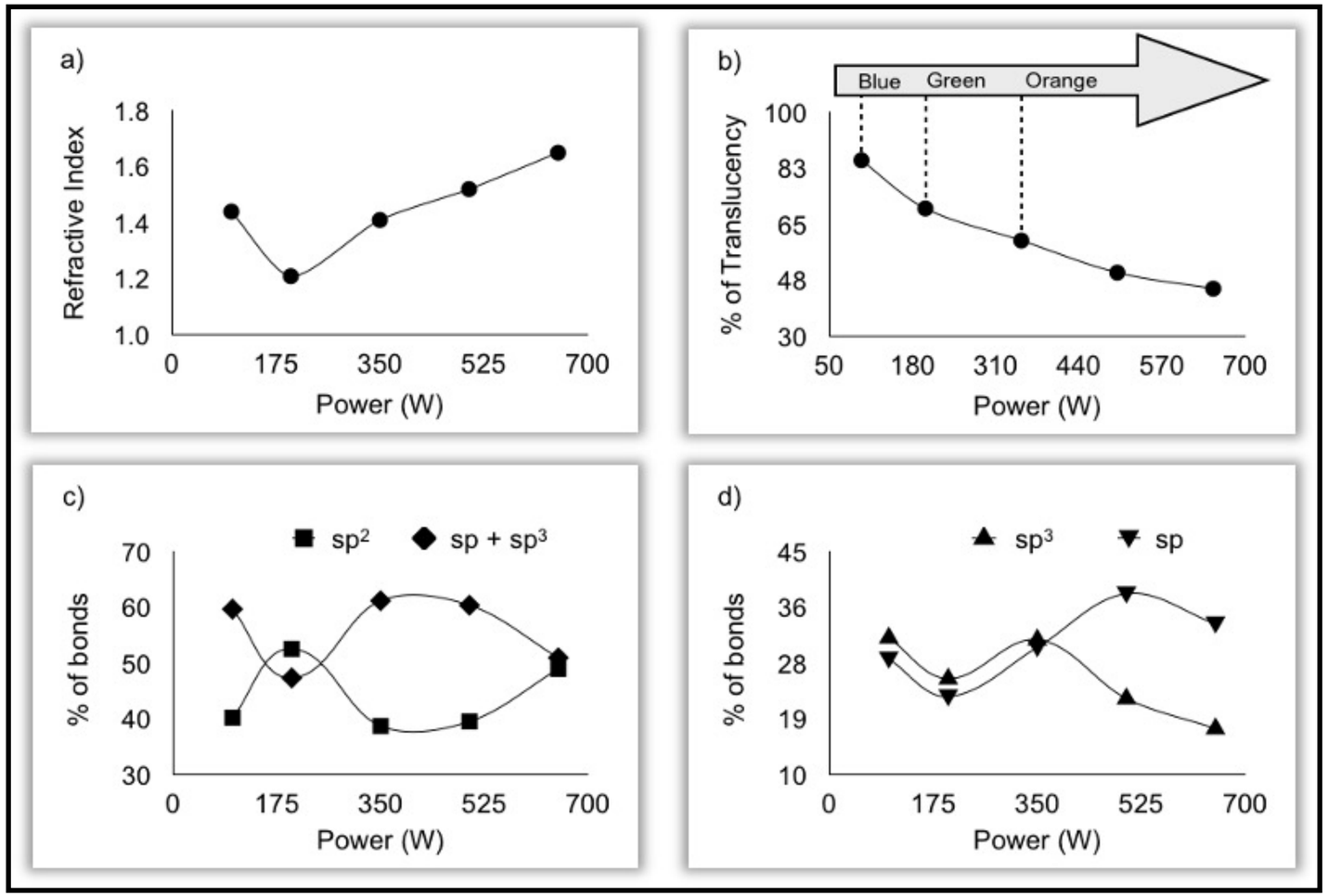
Films Grown in 1hr using 4 Pa of 20:80 CH_4:H_2



Optical Properties and Surface Chemistries of Films Grown Settling the ECR-MW Source at Different Powers Showed that the ECR-MW-CVD Method's Ambipolar-State is Discrete and Susceptible, and Thus, Discriminant.

The Refractive Indices of Films Deposited in 1d using 4 Pa of CH_4 were between 1.2 and 1.7.





The Optical Properties of the Films are Dictated by the Films' Surface Chemistries, which the ECR-MW-CVD's Method Ambipolar-State Dictates.

We are understating the properties and enhancing the processing of melanin composite materials by depicting the ambipolar state of multiple scientific events.

GOAL

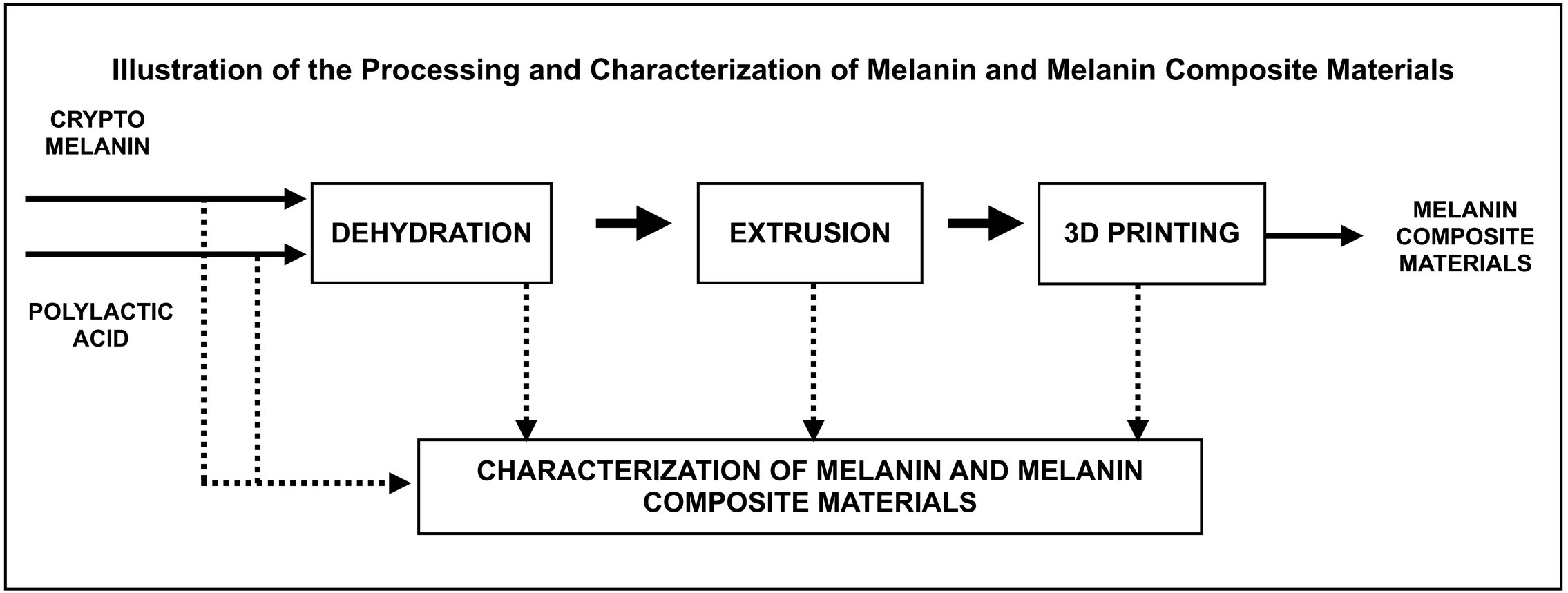
- Find ways to use melanin from Cryptococcus Neoformans to manufacture special classes of wearable, protective, and energy harvesting materials in a cost-effectively
  - — Radiation shielding devices
  - — Thermal energy harvesting devices
  - — Camouflage Clothing / Devices

SCOPES

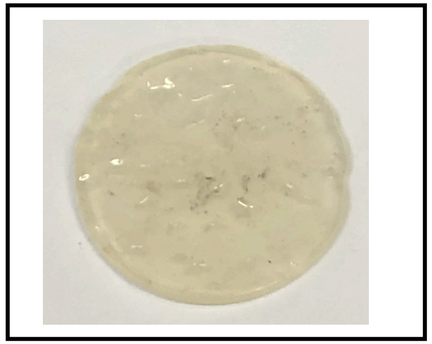
- Know if and how melanin and melanin products (e.g., slurry, powders, solid) and prototypes made of these products can shield and absorb light in specific regions of the electromagnetic spectrum.
- Observe intrinsic properties of melanin products and prototypes before and after exposing them to specific regions of energy frequency of the electromagnetic spectrum.
- Help others to understand how melanin can be processed for specific applications
  - — Defense
  - — Energy
  - — Space Traveling

In the same line, the ambipolar state …

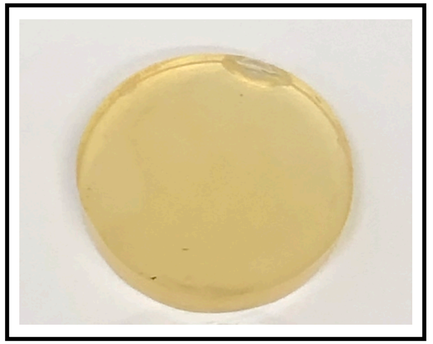
Accomplish the goals of this project correctly requires correlating the science of each operation unit, the processing conditions, and the properties of the materials at each point of this process



Melanin should be processed with polylactic acid (PLA), a polymer of common use in additive manufacturing technology

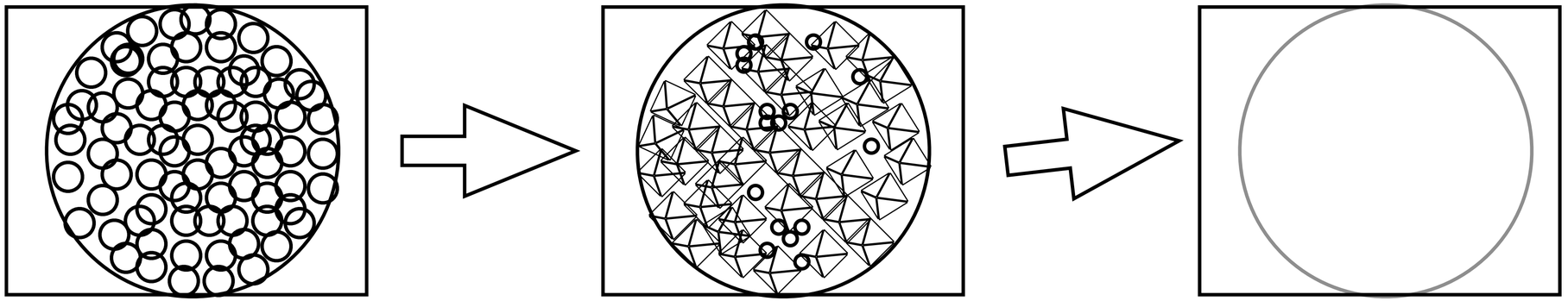


5 g PLA Disc at
200ºC | 2021



10 g PLA Disc at
121ºC | 2022

Forced Nature of the Formation of PLA Discs in the Glass Transition Regime (70 – 180ºC)



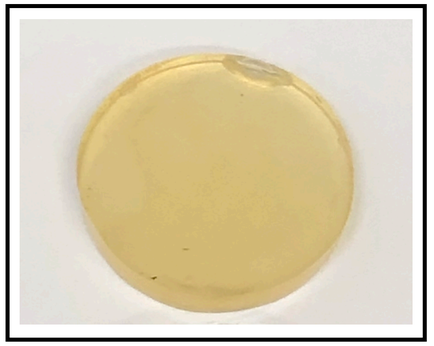
0 hours
PLA Pellets

2 hours
PLA Crystal Formation

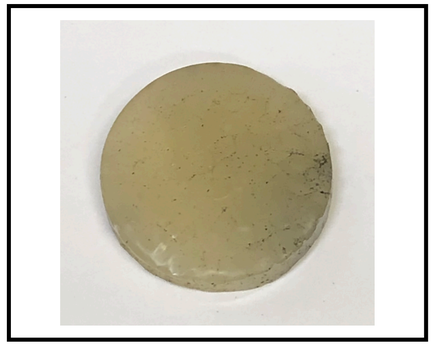
8 hours
PLA Crystalline Surface

The knowledge acquired studying the forced nature of the ambipolar-state of scientific events helped to perfect the synthesis of PLA-Melanin discs

Mass Density of polylactic acid (PLA) Discs made in June 2022 was consistent with values reported by research literature

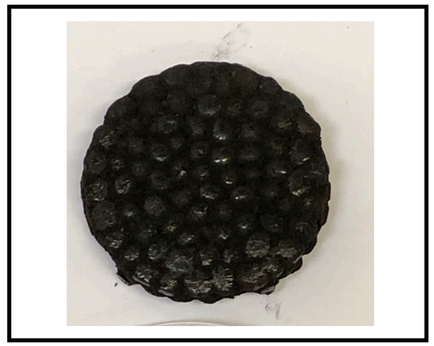


PLA
1.23 g/cm^3



PLA + Crypto Melanin (0.1)
1.13 g/cm^3

PLA + Crypto Melanin (1%)
1.12 g.]/cm^3

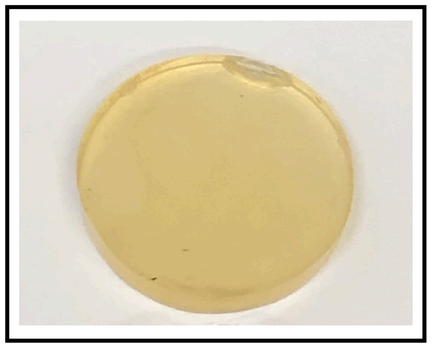


PLA + Crypto Melanin (10%)
1.12 g.cm^3

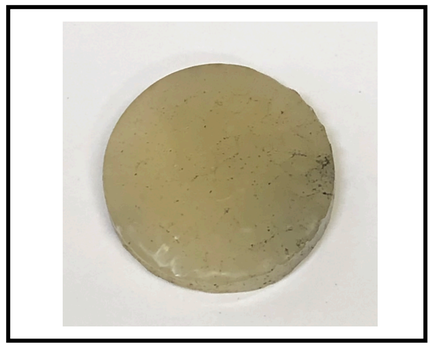
Theoretical Density of Cryptococcus Neuroformans = 1.022 g/cm^3
Theoretical Density of PLA = 1.21 – 1.43 g/cm^3

The altered nature of PLA does not allow it to form smooth discs when it is mixed with melanin and treated as we it happens with bare PLA

Thermal conductivity and effusivity of PLA discs made in June 2022 (MTPS ASTM D7984 for Polymers) shows to be consistent with values reported in the literature



PLA
0.2593 W /(m K)
613.3 Ws^(1/2)/Km^2



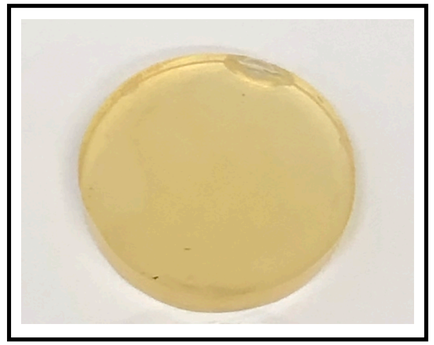
PLA + Crypto Melanin (0..1)
1.0754 W /(m K)
1381.5 Ws^(1/2)/Km^2

PLA + Crypto Melanin (1%)
0.6176 W /(m K)
973.4 Ws^(1/2)/Km^2

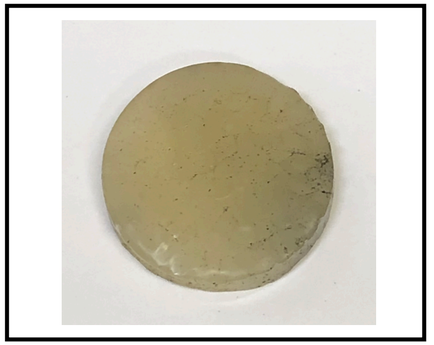
PLA + Crypto Melanin (10%) 0.3873 W /(m K)
746.4 Ws^(1/2)/Km^2

Thermal Conductivity of PLA = 0.12 – 2.73 W/(m K)

The heat capacity of PLA discs made in June 2022 (MTPS ASTM D7984 for Polymers) shows to be consistent with values reported in the literature

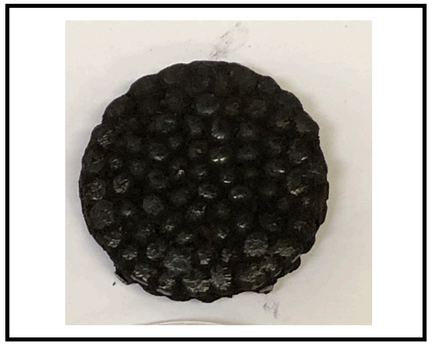


PLA
~1200 J/kgK



PLA + Crypto Melanin (0..1)
1571 J/kgK

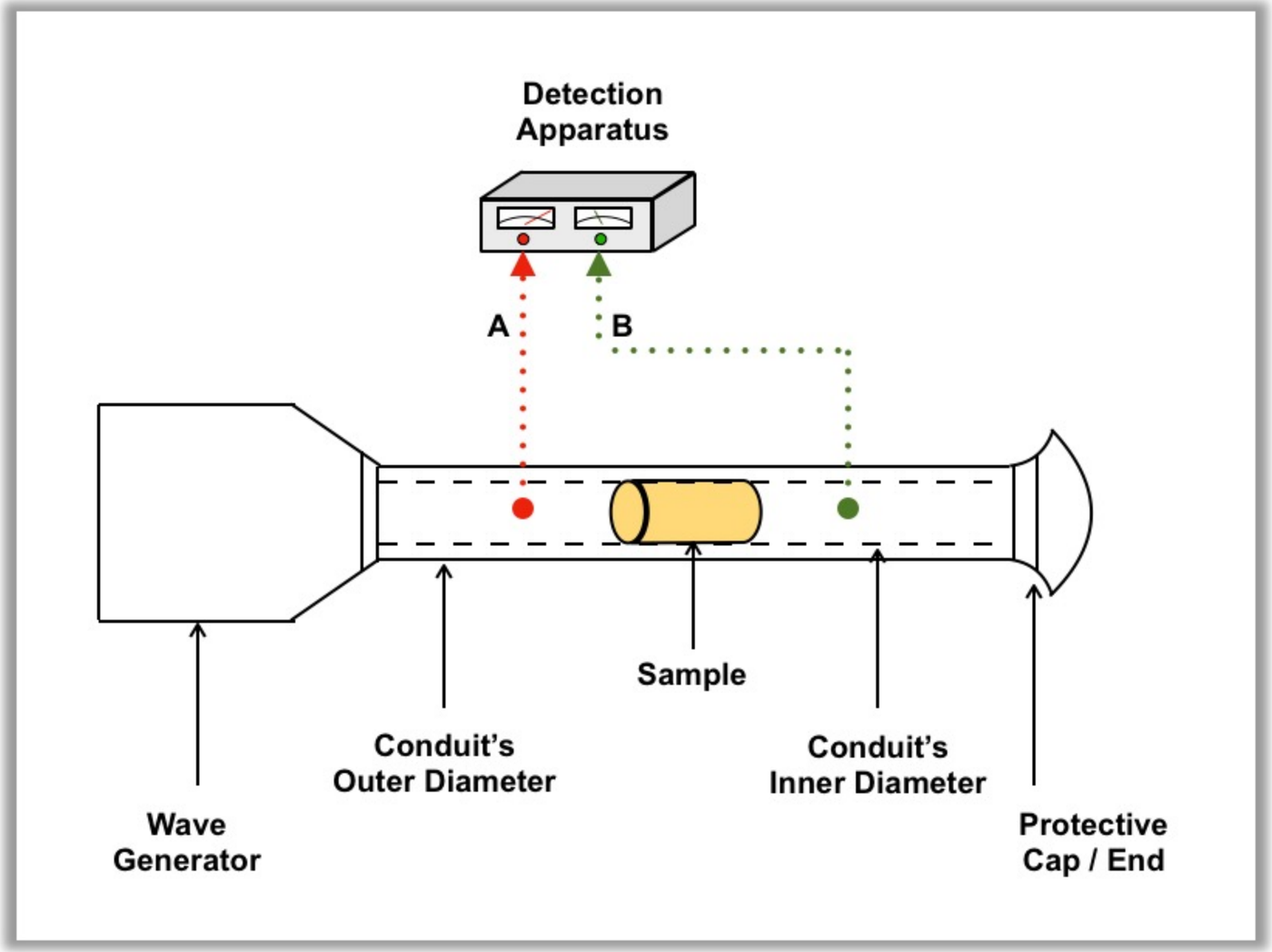
PLA + Crypto Melanin (1%)
1370 J/kgK



PLA + Crypto Melanin (10%)
1673 J/kgK

Heat Capacity of PLA = 1,200 J/kgK

Different types of Wave Absorption Shielding Observance Systems (WASOSs) are being designed to study the absorption/shielding properties of melanin composite materials



These WASOSs will shred light our understanding of melanin composite materials and would protect humanity against electromagnetic threats in and beyond planet Earth

Details on the design of each WASOS

WASOS Type	Frequency (Hz)	Types of Generator	Types of Detectors	Types of Conduit
MW	10^{9} – 10^{11}	• Power Grid Tubes • Cross Field Amplifiers	• Peak Detectors • Root Mean Square Detectors	• Black Steel • Aluminium
IR	10^{11} – 10^{14}	• Luminous Sources • Non-Luminous Sources	• Thermal Detectors • Photoconductivity Detectors	• Glass • Vantablack
VL	10^{14} – 10^{14}	• Discharge Lamps • Incandecent Lamps	• Basic Diode arrya • High-end Doide arrya	• Black Steel • Vantablck
UV	10^{14} – 10^{16}	• UV-ABlack Light • Argon Lamps	• Basic Diode arrya • High-end Doide arrya	• Polyethylene • Vantablack
XR	10^{16} – 10^{19}	• Single Phase Generator • Three Phase Generators	• Gas-Filled Detectors • Semiconductor Detectors	• Lead • Aluminium

MW = Microwave | IR = Infrared | VL = Visible Light | UV = Ultraviolet | XR = X-ray

NEXT STEPS

1. Perfecting the manufacture of melanin composite discs
2. Finding ways to measure the properties of melanin and melanin composite materials
   — Solid Discs
   — Powders
   — Slurries
3. Screening applications and exploiting our knowledge of melanin and melanin composite materials for:
   — Energy Storage
   — Space travel
   — Defense

The data collected at the end of this project will serve to depict the ambipolar states of melanin composite materials and their processes as scientific events formally

That will be the second depiction of the ambipolar state in the history of science.
Also, the first at Johns Hopkins University will help us to know more about the manufacturing and properties of melanin composite materials that would shield us from radiation threats and would get us to space cost-effectively.