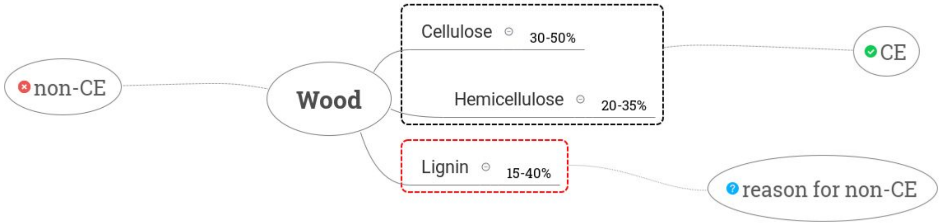
Paper Presentation

Why does wood not get charged?

CHEMISTRY OF MATERIALS
pubs.acs.org/cm Article

Why Does Wood Not Get Contact Charged? Lignin as an Antistatic Additive for Common Polymers

Mertcan Özel,[§] Fatma Demir,[§] Aizimaiti Aikebaier, Joanna Kwiczak-Yiğitbaşı, H. Tarik Baytekin, and Bilge Baytekin*



■ AUTHOR INFORMATION

Corresponding Author

Bilge Baytekin – *Department of Chemistry and UNAM National Nanotechnology Research Center, Bilkent University, Ankara 06800, Turkey*; orcid.org/0000-0002-3867-3863; Email: b-baytekin@fen.bilkent.edu.tr

Authors

Mertcan Özel – *Department of Chemistry, Bilkent University, Ankara 06800, Turkey*

Fatma Demir – *Department of Chemistry, Bilkent University, Ankara 06800, Turkey*

Aizimaiti Aikebaier – *UNAM National Nanotechnology Research Center, Bilkent University, Ankara 06800, Turkey*

Joanna Kwiczak-Yiğitbaşı – *Department of Chemistry, Bilkent University, Ankara 06800, Turkey*

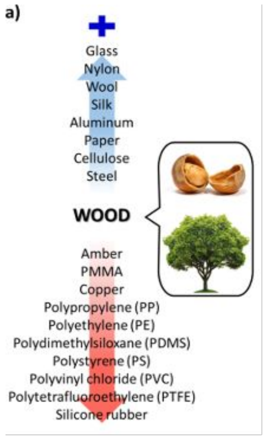
H. Tarik Baytekin – *Department of Chemistry, Bilkent University, Ankara 06800, Turkey*

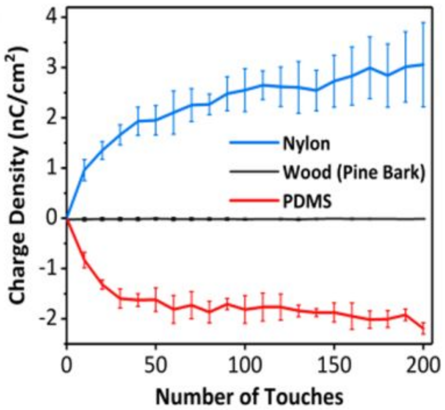
Complete contact information is available at:
https://pubs.acs.org/10.1021/acs.chemmater.0c02421

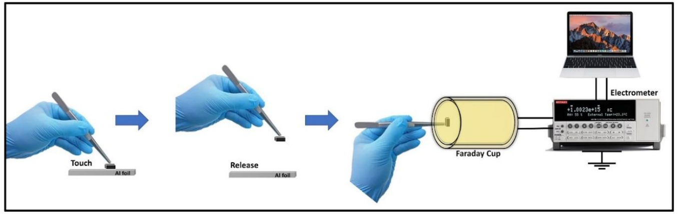
Introduction

- ➔ Antistatic behaviour of wood owing to the presence of lignin.
  - ◆ Adding or removing lignin allowed switchable CE.
  - ◆ Lignin is the second most abundant polymer on earth.
- ➔ Bond breaking and radical scavenging mechanism as the reason for antistatic behaviour.
- ➔ Finally, using lignin as low cost universal antistatic additive to bring antistatic properties to materials such as elastomers and thermoplastics.

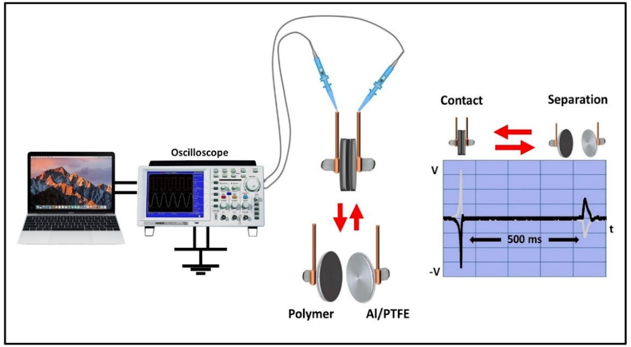
tendency for contact charging (Figure 1a). Wood is one of the most commonly used raw materials (annual production of 2 billion metric tons).[22] It has several advantages over other synthetic alternatives because it does not contribute to environmental pollution, unlike plastics. Wood can serve both as an electrical insulator and antistatic material. Investigating this interesting property of wood is more than just a fundamental research interest; it is a necessity for the development of current and new wood technologies.[23] One example of the utilization of treated wood is recently shown in the inventive work by Luo et al. in flexible and durable triboelectric generators in self-powered sensors.[24]

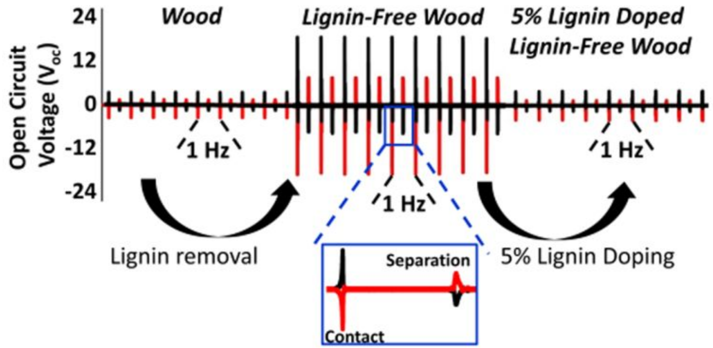



Charge Density (nC/cm^2)
Number of Touches
Nylon
Wood (Pine Bark)
PDMS


a)
Touch
Al foil
Release
Al foil
Faraday Cup
Electrometer

b)


Oscilloscope
Contact
Separation
Polymer
Al/PTFE
500 ms


a)
Open Circuit Voltage (V_{oc})
Wood
Lignin-Free Wood
5% Lignin Doped Lignin-Free Wood
1 Hz
1 Hz
1 Hz
Lignin removal
5% Lignin Doping
Separation
Contact

Probing other factors for antistatic behaviour

- Increase in surface conductivity.
- Enhance water absorption by polymer on addition of additive.

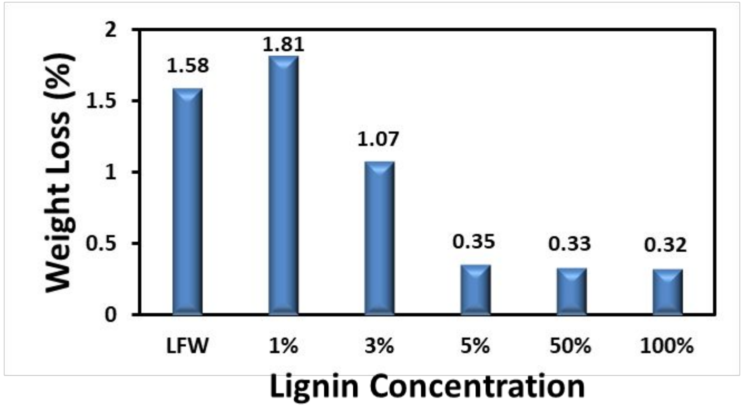


Figure S11. Determination of the moisture content of lignin-free wood (LFW), 1-50% w/w lignin doped lignin-free wood and lignin samples using TGA. The samples are heated at 50 ^{0}C under N_2 gas, while the weight of the samples (initial masses of 6.0 mg) are tracked by TGA.

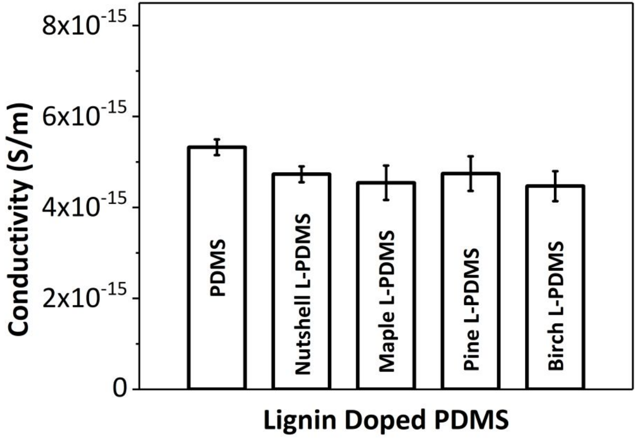


Figure S19. Conductivities of all samples were measured using two-probe method described in SI and 5% maximum doping concentration was used for comparison.

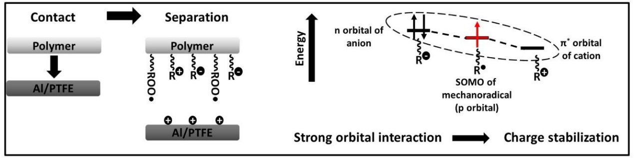
Mechanism

- Mechanical contact breaks the bond at the surface leading to formation of mechano-ions and mechano-radicals.
- Mechanoradicals stabilize these charges and their removal using a radical scavenger destablize the charge rendering the material antistatic.

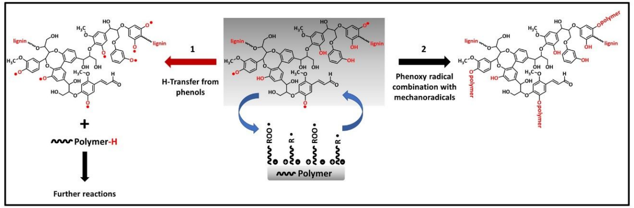
In case of lignin, radical scavenger can be either be

a) Stable radical in lignin, or
b) phenols in the lignin structure that can form more stable radicals upon reaction with these polymer (or wood) mechanoradicals by H-atom transfer.

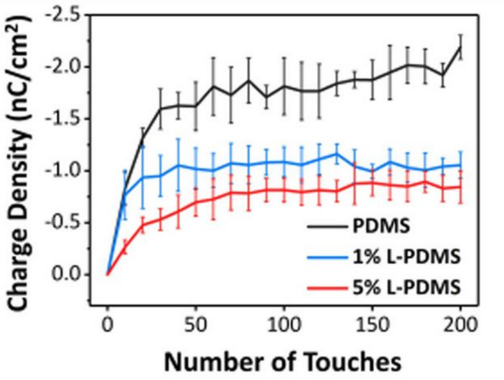
a)



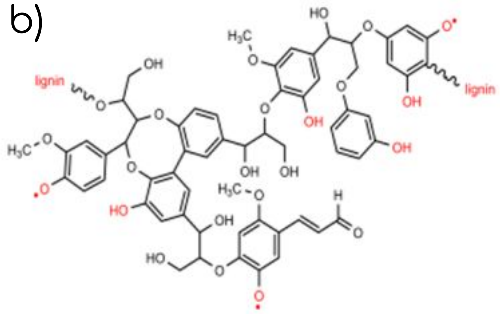
b)



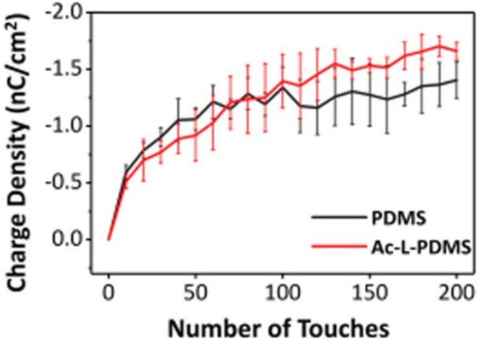
a)



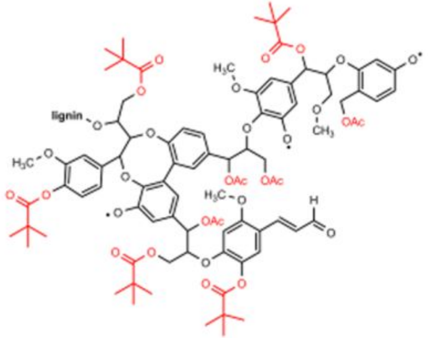
b)



c)



d)



b) Typical chemical structure of lignin. d) Chemical structure of acylated lignin (Ac: trimethyl acetyl)

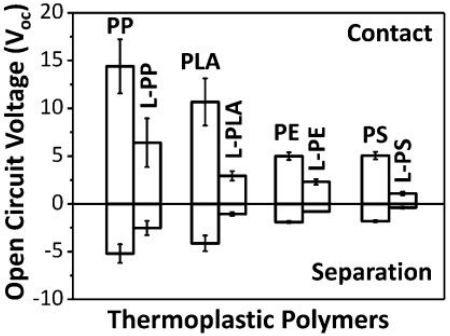


Figure 5. CE propensity of the thermoplastic polymers (measured as open-circuit voltage on a tapping setup) before and after 5% lignin doping. The open-circuit voltages are saturated signals collected from the oscilloscope. See the Supporting Information for further experimental details. Error bars correspond to standard deviations determined from at least four independent experiments.

Summary

1. Provided insight to antistatic nature of wood because of the presence of lignin.
2. Mechanism of CE.
3. Demonstrated that lignin as an antistatic additive for common polymers even at low doping concentrations.