Effect of Redmud addition on electrical and magnetic properties of hemp-derived-biochar-containing epoxy composites

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Effect of Redmud addition on electrical and magnetic properties of hemp-derived-biochar-containing epoxy composites

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Who I’m:

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Motivation: why are we interested in electrically conductive composites?

Electrically conductive composites are attractive because they offer a unique combination of electrical, mechanical, and chemical properties, making them versatile and suitable for a wide range of applications in fields such as electronics, industry, medicine, and many others. Their ability to be customized to meet specific needs makes them even more valuable in technological innovation.
Motivation: why are we interested in electrically conductive composites?
Red Mud: a metal-rich waste

The main content is Fe$_2$O$_3$, which gives the reddish color. Also present are Al$_2$O$_3$, TiO$_2$, SiO$_2$ and other oxides.
Red mud and...

1. Kraft Lignin
2. Hemp fibers
3. Pine wood

Co-Pyrolysis treatment @ ICFAR
15°C/min up to 600°C
Red mud is not conductive. The more red mud added the worse the conductivity of the mixture.
Electrical conductivity DC

Red mud is not conductive. The more red mud added the worse the conductivity of the mixture.

BC from Hemp was selected
Second step annealing @ 900°C
Static furnace 5°C/min for 2 hours

<table>
<thead>
<tr>
<th>Element (wt.%)</th>
<th>RM Amount (wt.%)</th>
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<td>RM</td>
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<td>C</td>
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<tr>
<td>Ti</td>
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<tr>
<td>Fe</td>
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</table>

EDX analysis of neat Red Mud and Red Mud Biochar
Electrical DC conductivity for epoxy based composites

Ohm law to evaluate Electrical conductivity

\[
\sigma = \frac{1}{\rho} = \frac{l(m)}{R(\Omega)A(m^2)}
\]

4 order of magnitude
Electrical DC conductivity for epoxy based composites *in function of pressure*

Ohm law to evaluate Electrical conductivity

\[ \sigma = \frac{1}{\rho} = \frac{l(m)}{R(\Omega)A(m^2)} \]
Electrical conductivity AC for composites
Epoxy+30wt% (RM+BC)

Increasing the ratio of red mud to biochar in the filler, the values of conductivity tend to decrease.
Magnetization curves (hysteresis cycles)
Magnetization curves (hysteresis cycles)

Epoxy+30wt% (RM+BC)

Red Mud or Biochar alone (Paramagnetic)
Coclusions

1. The modification of the ratio between RM and hemp allowed us to **enhance the electrical or magnetic properties** of the material employed as a filler in composite samples.
2. The increment of the RM-to-hemp ratio led to a significant **reduction of conductivity (insulating behavior of inorganic particles)** of the resulting BC under both DC and AC regimes while it increased the magnetic signal of the composites.
3. The simultaneous good conductive and magnetic properties of BC-containing composites could represent a solid solution to produce **microwave-shielding materials and magnetic-responsive composites**.
4. These high-value applications support the inclusion of RM into the thermochemical conversion of hemp leading the way for the virtuous **use of complex waste streams**.
Thank you for your attention!

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