Char residues from biomass gasification as low-cost and environmentally friendly fillers in polymers

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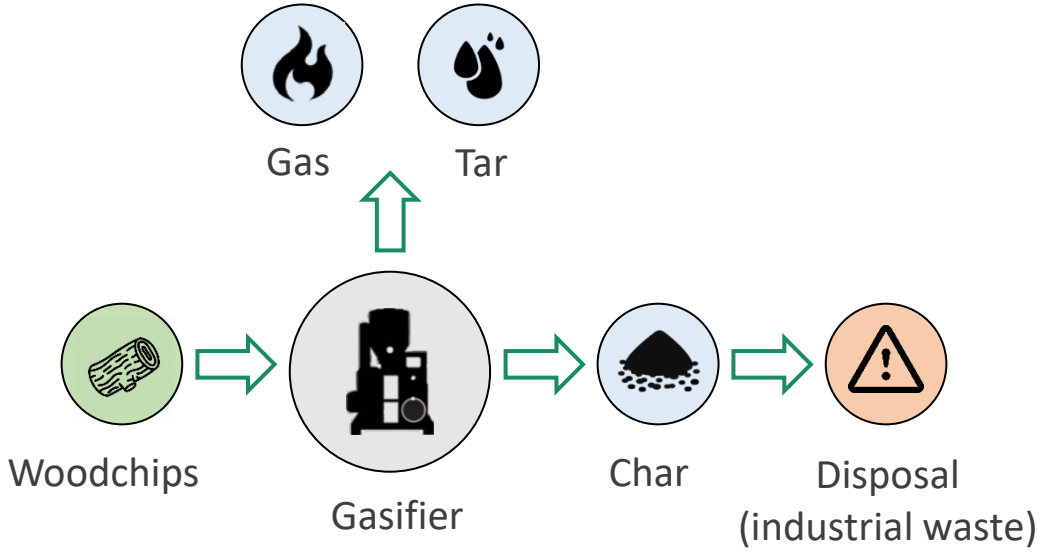
Introduction

Biomass gasification

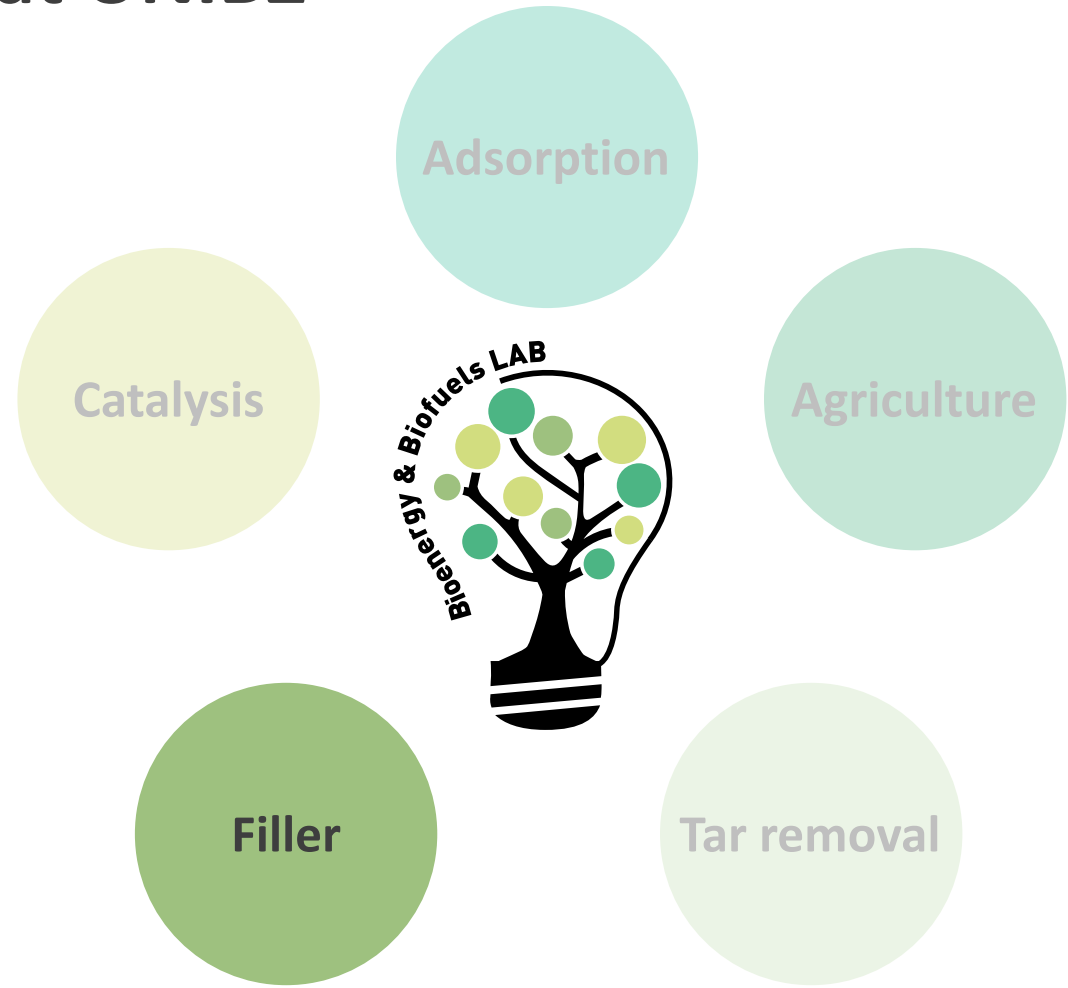
- Gas
- Tar (liquid)
- Char (solid)

South Tyrol: about **1300 tons/year** of char disposed of as industrial waste with a high cost for disposal (140 - 150 €/ton)

Valorization



Char valorization at UNIBZ



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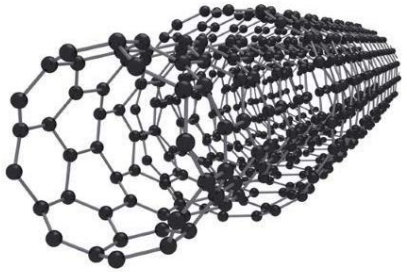
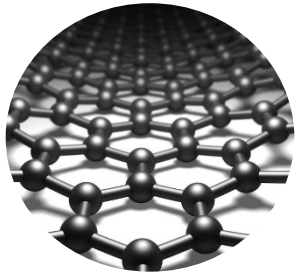
Fillers in polymers

Carbon Nanotubes



Carbon Black

Graphene



Carbon Fibers

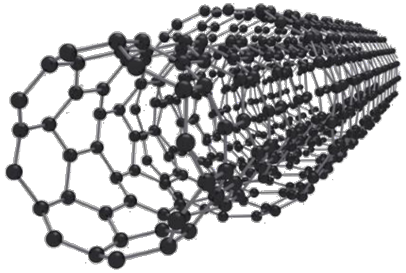
Graphite

- To introduce/improve functional properties
- To enhance tensile properties, thermal stability and electrical conductivity

- High production costs
- Need of chemicals
- Fossil-based feedstock

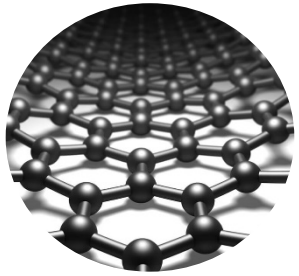
Fillers in polymers

Carbon Nanotubes



Carbon Black

Graphene



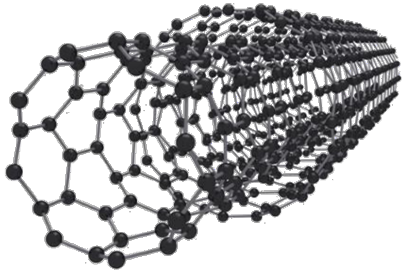
Char

Carbon Fibers

Graphite

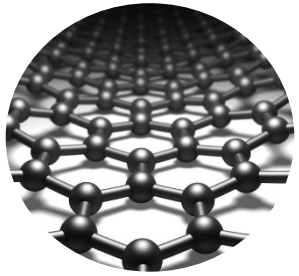
Fillers in polymers

Carbon Nanotubes



Carbon Black

Graphene



Carbon Fibers

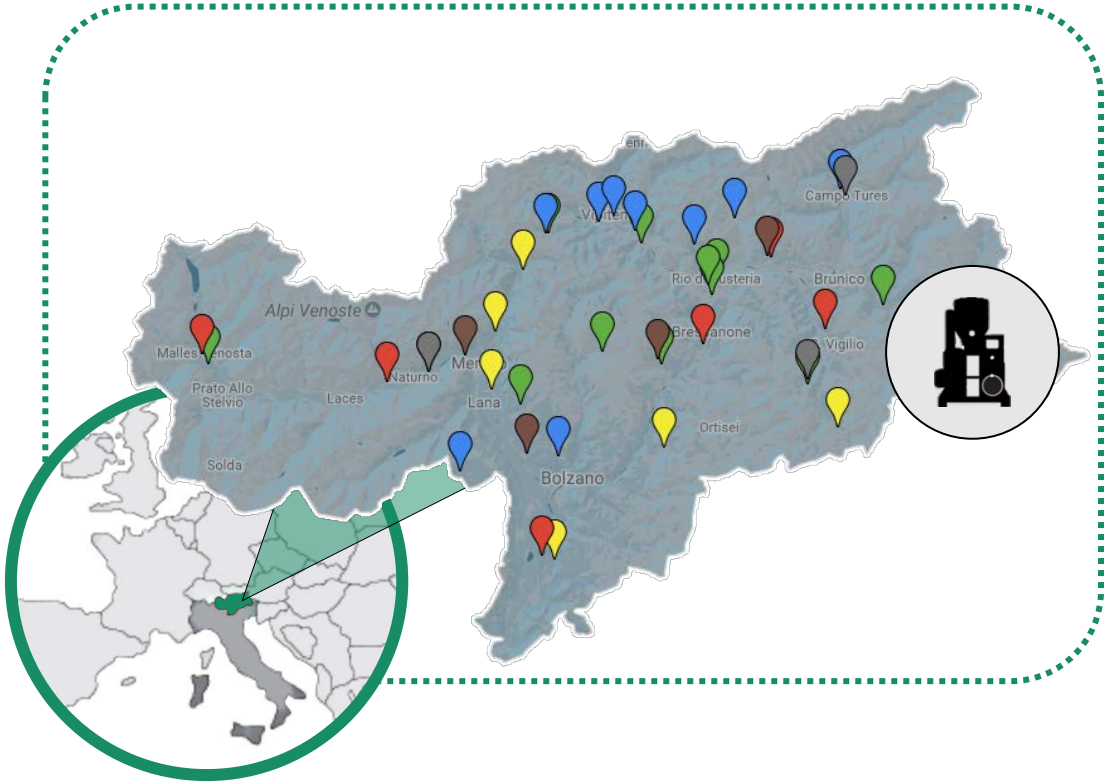
Graphite

Char

- Waste valorization
- Reduced costs
- Increased sustainability

Materials and methods

Commercial biomass gasification plant



- Technology: dual-stage, floating fixed-bed
- Feedstock: wood chips
- Gasifying agent: air
- p = 1 atm
- T = 850 °C
- P_{th} = 540 kW and P_{el} = 280 kW

Projects: GaST (Province of Bolzano LP14), NEXT (Province of Bolzano LP14), WOOD-UP (FESR-EFRE 2014-2020)

Materials and methods

Composite preparation

- Styrene-ethylene-butylene-styrene (SEBS)
- Char

- Melt compounding technology
- Lab-scale co-rotating twin-screw extruder

- *Green Polyohm™*

Materials and methods

Characterization

Elemental analysis (C, H, N, S)

Physisorption analysis

X-ray diffraction (XRD)

Scanning electron microscopy (SEM)

Thermogravimetric analysis (TGA)

Differential scanning calorimetry (DSC)

Electrical conductivity measurements (σ)

Results

Results

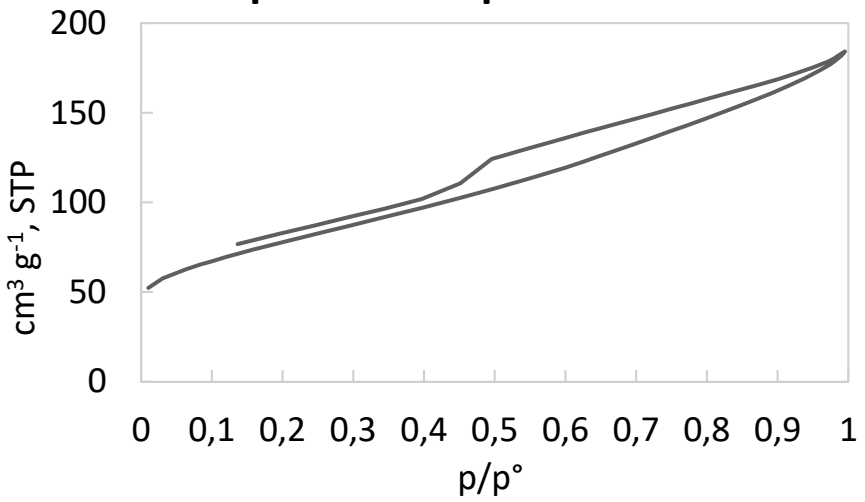
CHNS | Phys | XRD | SEM | TGA | DSC | σ

(% wt_{dry})	Char	Carbon Black	SEBS	GP
C	91 ± 2	99.66 ± 0.03	86.5 ± 0.1	87.8 ± 0.3
H	0.72 ± 0.05	0.09 ± 0.01	13.10 ± 0.05	8.2 ± 0.4
N	0.26 ± 0.03	0.07 ± 0.01	0.05 ± 0.01	0.15 ± 0.06
S	0.56 ± 0.07	0.20 ± 0.04	0.35 ± 0.08	0.20 ± 0.08
O	2.89	-	-	2.18
Ash	4.20 ± 0.05	-	0.12 ± 0.10	1.55 ± 0.01

GP: Green Polyohm™

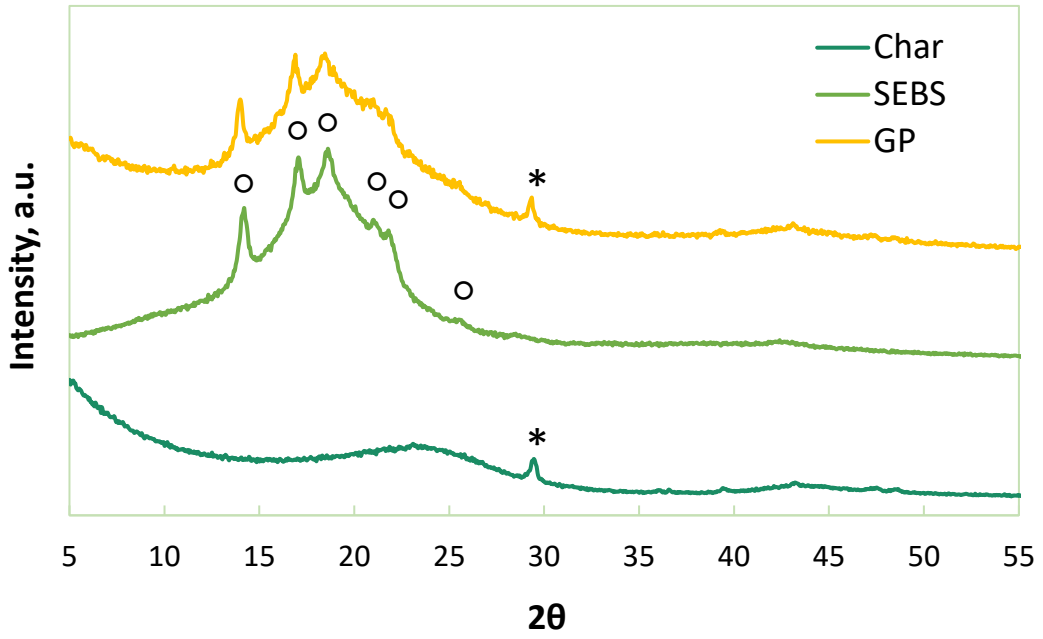
	Unit	Char	Carbon Black
S_{BET}	$m^2\ g^{-1}$	297	64
Pore volume	$cm^3\ g^{-1}$	0.26	0.06
Pore diameter	nm	4.5	6.8

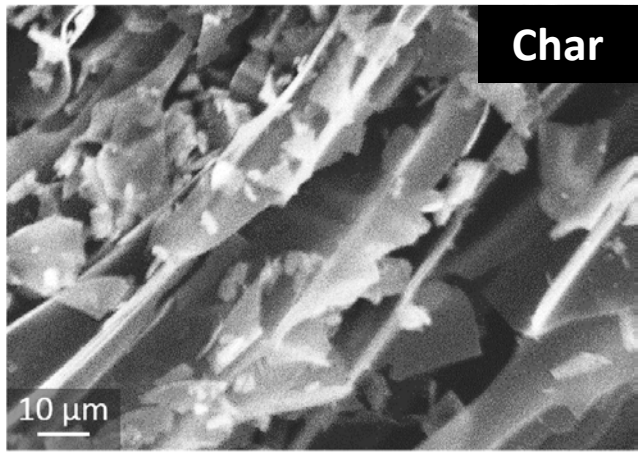
Adsorption-desorption isotherm

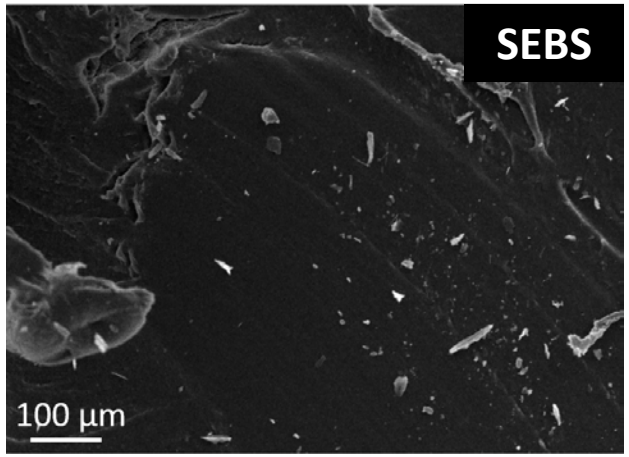


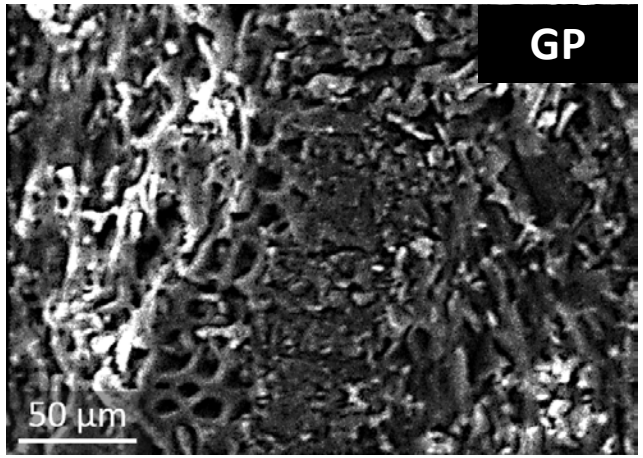
Results

CHNS | Phys | **XRD** | SEM | TGA | DSC | σ





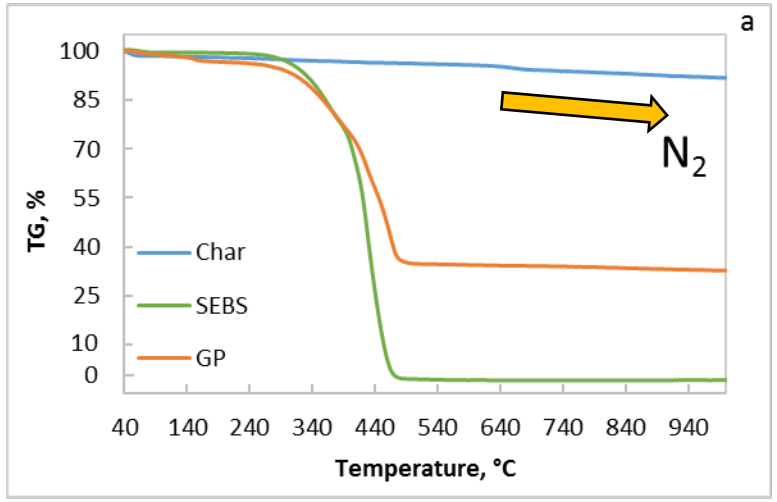


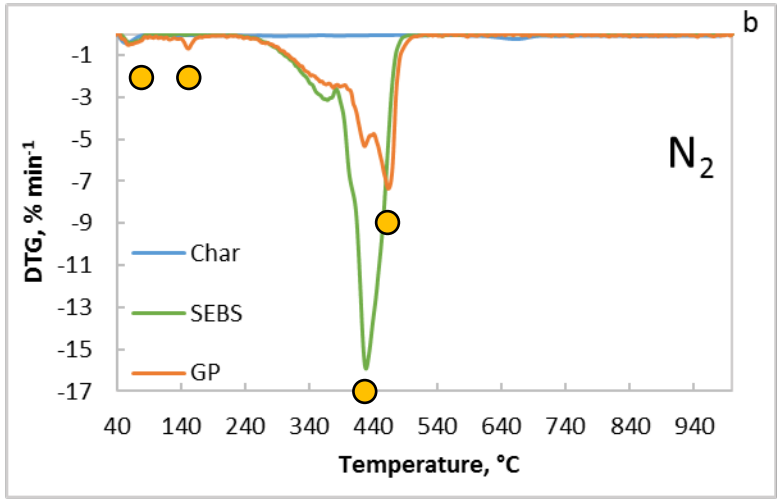


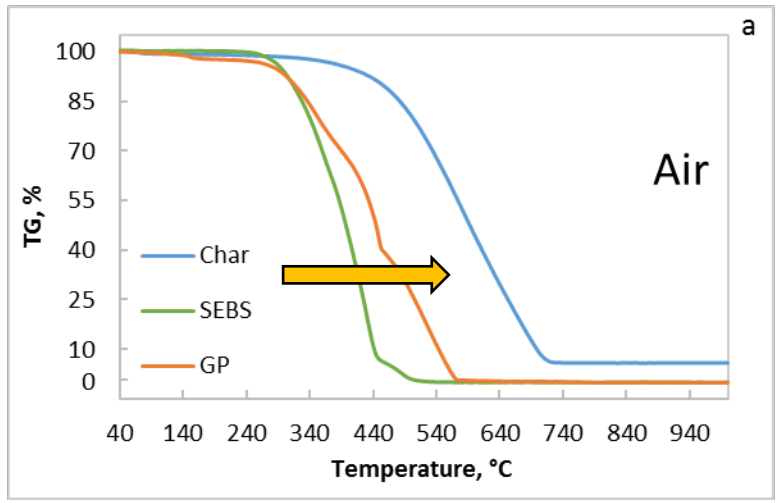
- *: $CaCO_3$
- o: monoclinic crystals (α- form)

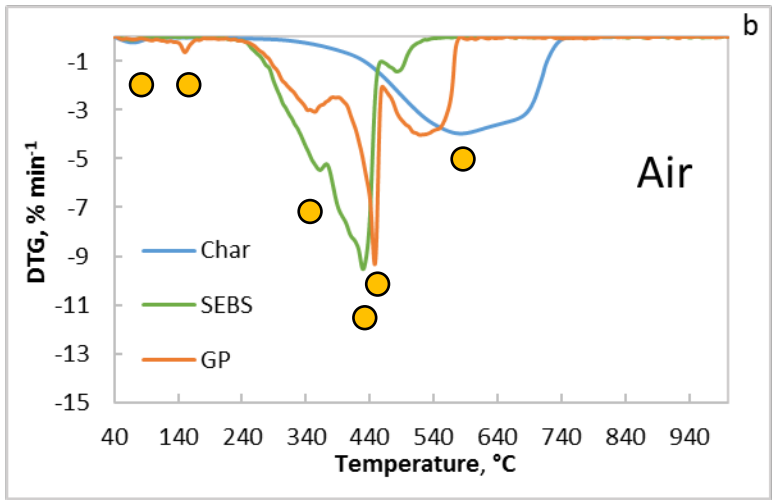
Results

CHNS | Phys | XRD | SEM | **TGA** | DSC | σ









	Unit	SEBS	GP
Tm_1	°C	157	155
Tc	°C	104	114
Tm_2	°C	156	155
ΔHm_1	J/g	13.95	7.51
ΔHc	J/g	15.46	8.75
ΔHm_2	J/g	14.12	8.01

GP: Green Polyohm™
m: melting
c: crystallization

Results

CHNS | Phys | XRD | SEM | TGA | DSC | σ

Char	ρ	σ
% wt	Ω cm	S cm^{-1}
41	$2 \cdot 10^{5}$	$5 \cdot 10^{-6}$
43	$9 \cdot 10^{4}$	$1 \cdot 10^{-5}$
44	$6 \cdot 10^{2}$	$2 \cdot 10^{-3}$

Conductive polymer composites are preferable than **metallic conductors** since they can be **shaped more easily and at lower costs**, they **weigh less**, provide **corrosion resistance** and their electrical conductivities vary in a **wide range.**

Literature on biochar (700°C)

$1.2 – 2.9 \cdot 10^{-3}$ S cm^{-1}

Char is a waste!

Results

Waste and Biomass Valorization
https://doi.org/10.1007/s12649-020-01243-7

ORIGINAL PAPER

Check for updates

Valorization of Biomass Gasification Char as Filler in Polymers and Comparison with Carbon Black

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Conclusion

- Remarkable properties of char make it suitable for a plethora of innovative applications
- Char was added to a SEBS matrix to obtain *Green Polyohm*^{TM}, a composite with enhanced thermal stability and electrical conductivity
- Char is an effective filler for polymers
- Char could be considered a high-available and low-cost substitute for carbon-based fillers
- In this way, large amounts of char could be consumed/valorized

Thank you for your attention

Valorisation of char residues from biomass gasification as filler in polymers

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