Eco-friendly chitosan films with dielectric solids for the design of TENGs

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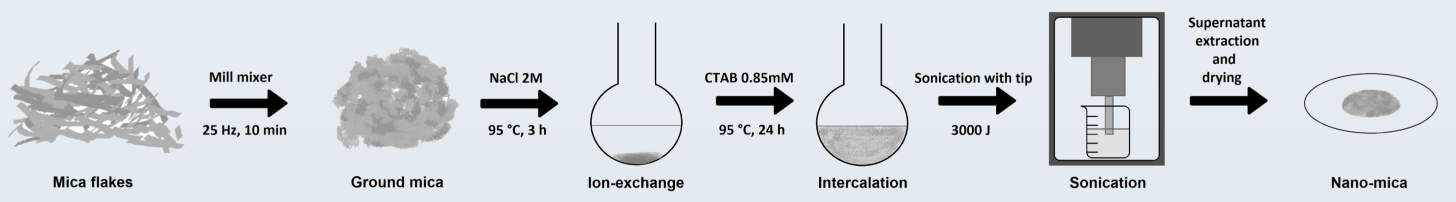
INTRODUCTION AND OBJECTIVES

As new types of technology emerge, the need for more accessible energy that comes from sustainable sources is rising. Herein, TENGs (triboelectric nanogenerators) can be used as pieces of technology that harvest mechanical energy and converts it into electrical energy on a small scale.[1] Materials that have good triboelectric properties and are environmentally friendly are sought.[2] In this work, we draw on films composed of a biopolymer matrix in combination with inorganic fillers like mica and titanates in the form of nanosheets.

For producing theses films, we use different methods like solvent casting, vacuum filtration and spin-coating. Then, the resultant materials and films were characterized by X-ray diffraction, SEM and, lastly, by contact electrification to obtain the subsequent triboelectric energy output.

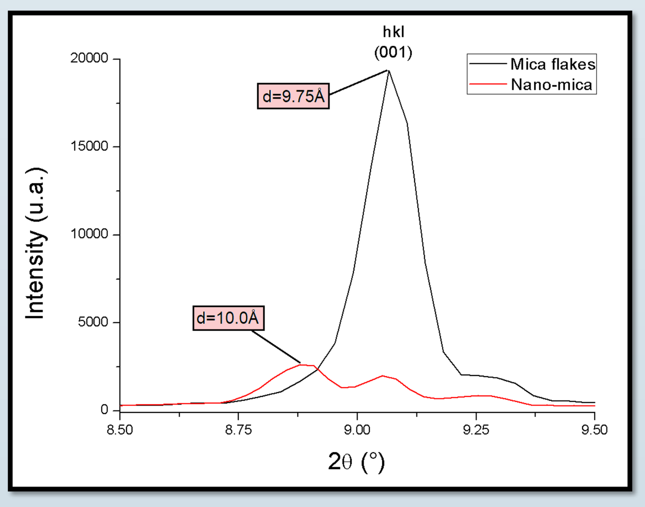
NANOMICA PREPARATION AND CHARACTERIZATION

Procedure: Mica flakes were ground to a particle size of less than 250 µm. Subsequently, they were subjected to an ion-exchange treatment and intercalation with a surfactant (CTAB) so that when sonicated, mica powder with a nanoscale thickness was achieved.

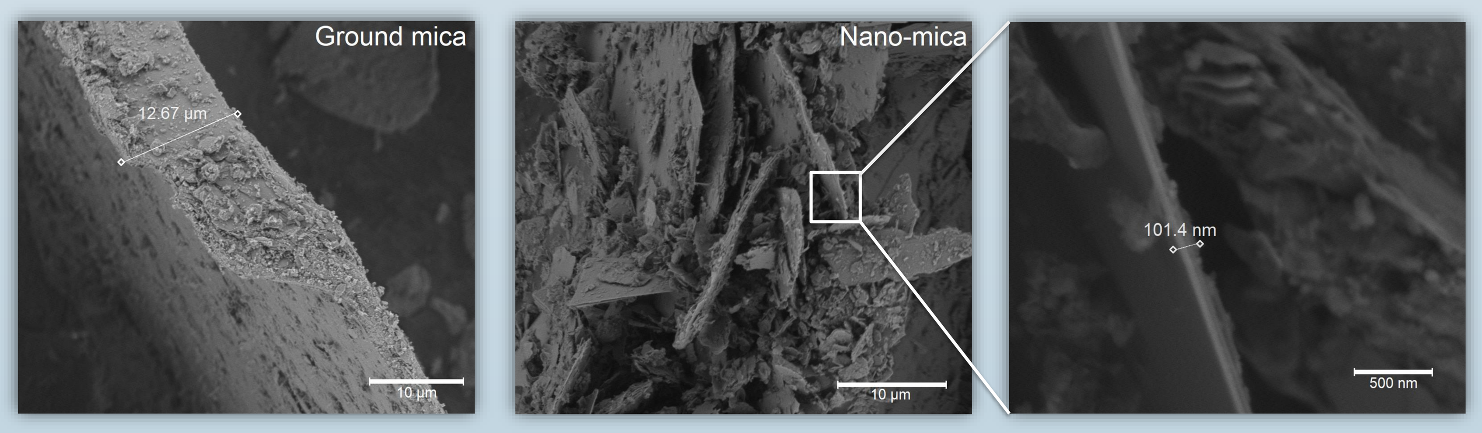


Starting material: Muscovite mica flakes 1-3 mm (from Kremer Pigments GmbH & Co.KG)

Characterization by XRD: shift of the diffraction peak relates to partial intercalation.



Scanning Electron Microscopy (SEM): Ground vs. Nano-mica

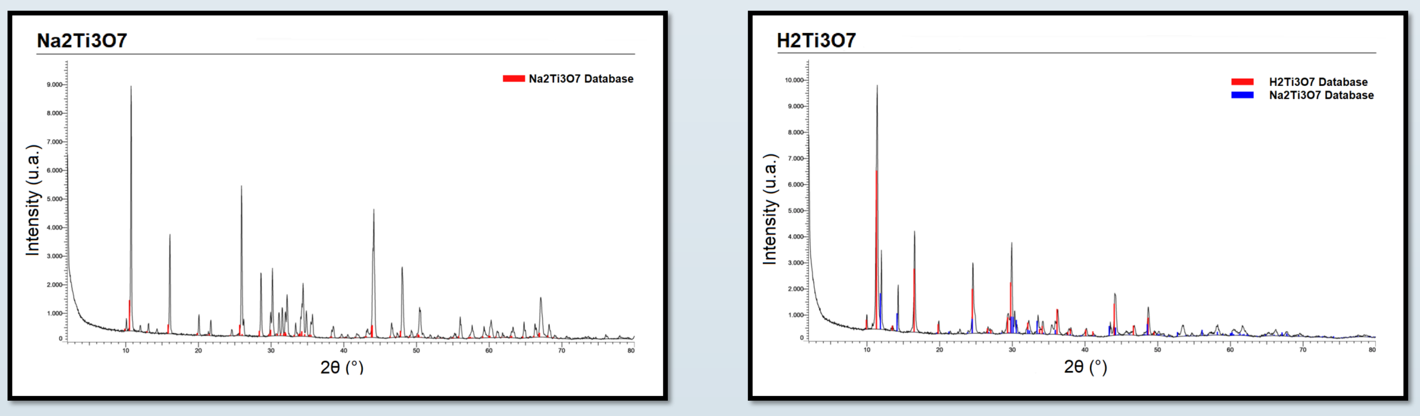


TITANATE SYNTHESIS AND CHARACTERIZATION

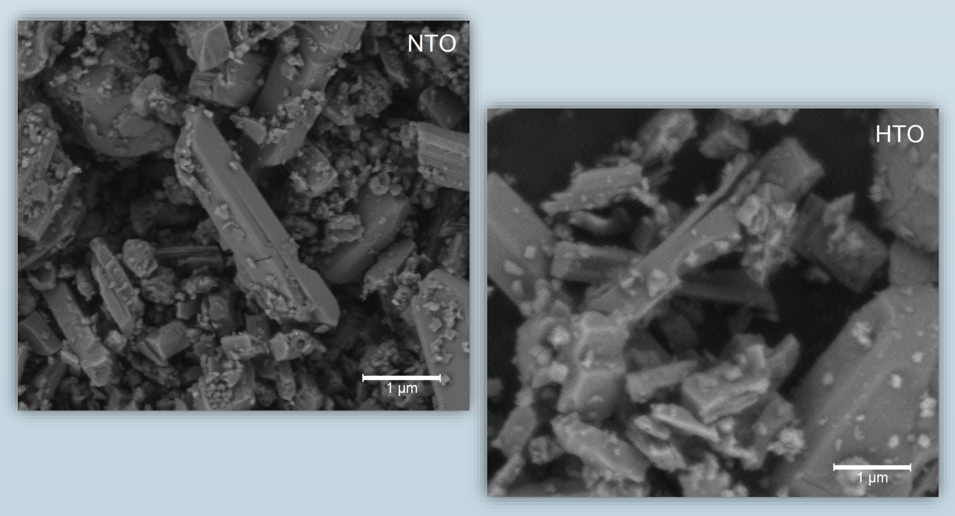
Procedure: $Na_2Ti_3O_7$ (NTO) was synthesized by a solid-state reaction from Na_2CO_3 and TiO_2 precursors. The titanate was then subjected to a protonation reaction using HCl to obtain $H_2Ti_3O_7$ (HTO).

$$Na_2CO_3 + TiO_2 \xrightarrow{900\ °C,\ 24h} Na_2Ti_3O_7 \xrightarrow{HCl,\ 60\ °C,\ 6d} H_2Ti_3O_7$$

XRD Diffraction Patterns: not all NTO was transformed into HTO due to an incompleted ion-exchange.



SEM Micrographs: a broad particle size distribution is observable.

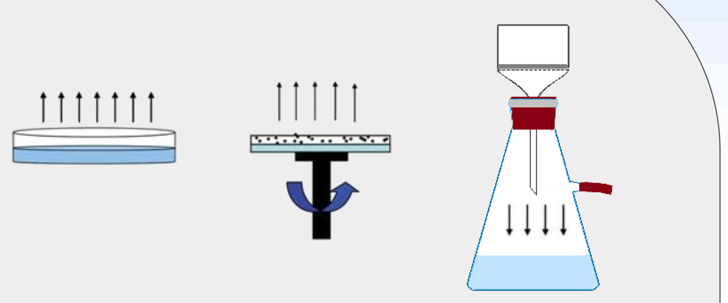


EDS Cuantitative results show a reduction in Na weight%.

	Element	Weight (%)
$Na_2Ti_3O_7$	Ti	41.77
	O	39.38
	Na	15.70
	C	2.67
	K	0.49
$H_2Ti_3O_7$	Ti	56.89
	O	36.13
	Na	3.21
	C	3.30
	K	0.47

FILM FABRICATION

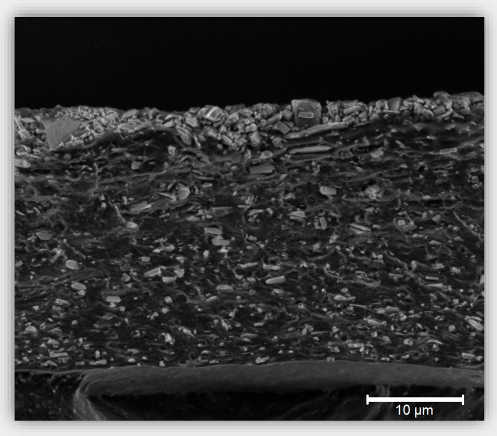
Chitosan was used as the polymeric matrix and inorganic fillers consisted of mica flakes, nanomica sheets, $Na_2Ti_3O_7$ and $H_2Ti_3O_7$ compounds.



Solvent casting (40 °C, 24h) · Spin coating (3000 rpm, 45 s) · Vacuum filtration (Filter 0.025 µm)

Film made of mica flakes (vacuum filtration)

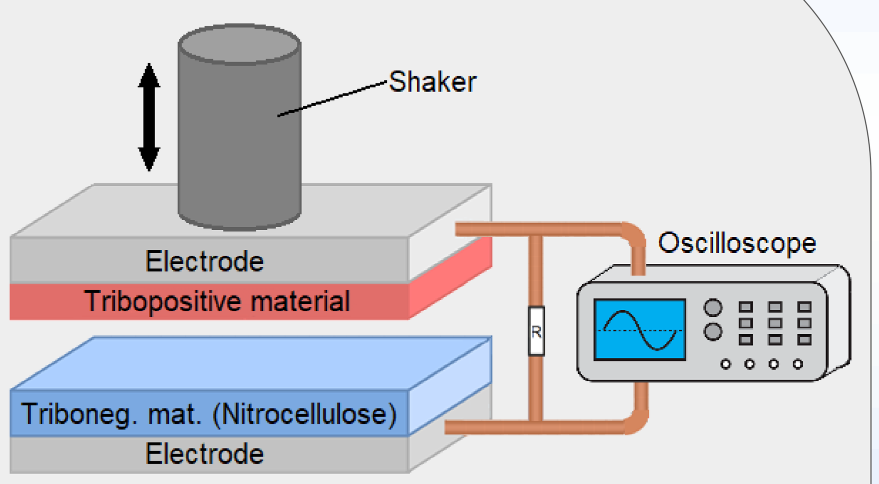
Cross-section of a HTO-Chitosan film (solvent casting)

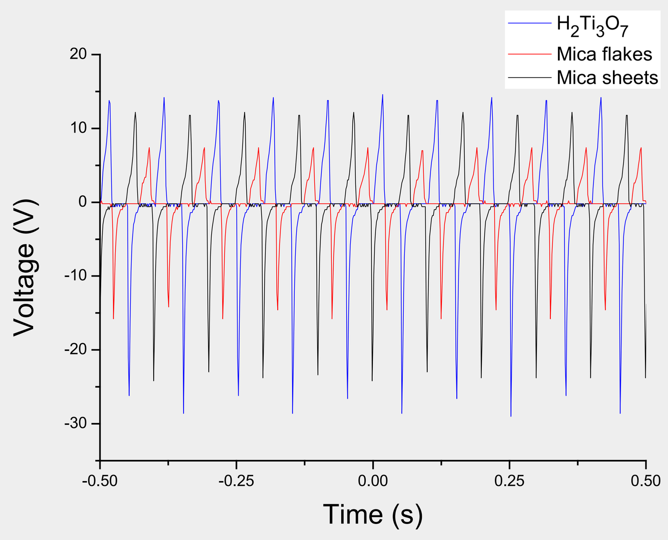


The best films were obtained by vacuum filtration and solvent casting methods.

TRIBOELECTRICITY MEASUREMENTS

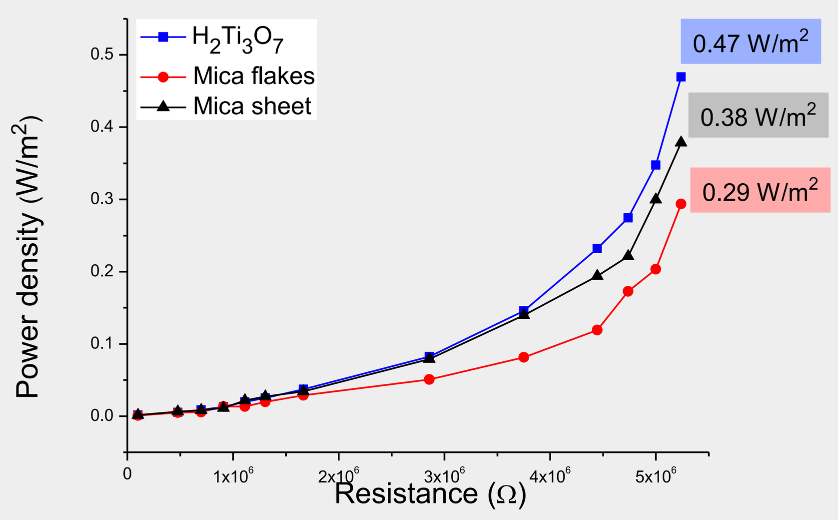
Voltage measurements obtained in contact separation mode with a shaker using a force of 10N. Nitrocellulose film was used as a counter triboelectric material.





Film material	Voltage (V)
$H_2Ti_3O_7$	44
$Na_2Ti_3O_7$	12
Nano-mica	15
Mica flakes	26
Mica sheet	42

Power load curves and maximum output:



Energy output:

Material	$H_2Ti_3O_7$	Mica flakes
Energy (Wh/m^2)	0.781	0.690

Best results were obtained from films made of $H_2Ti_3O_7$:Chitosan (1:2 w/w) and Mica flakes:Chitosan (3.75:1 w/w). Comparison was made with a cleaved mica sheet (from Ted Pella Inc.).

CONCLUSION

- $H_2Ti_3O_7$/Chitosan and cleaved mica sheets show the highest triboelectric potentials.
- Mica flakes/chitosan nanocomposites show good triboelectricity and could be an abundant alternative to cleaved mica sheets.
- Nano-mica presents modest triboelectricity compared to the other micas flakes and sheets, suggesting that particle size may matter.
- $H_2Ti_3O_7$ could be a promising new tribomaterial, easy for synthesize and with higher power output than mica.

REFERENCES

[1] Wang, Z. Triboelectric Nanogenerators as New Energy Technology for Self-Powered Systems and as Active Mechanical and Chemical Sensors. ACS Nano. 2013
[2] Rodrigues-Marinho, T., Castro, N., Correia, V., Costa, P. and Lanceros-Méndez, S. Triboelectric Energy Harvesting Response of Different Polymer-Based Materials. Materials. 2020

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