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Preparation of Multifunctional Composites for Electromagnetic Interference (EMI) Shielding Applications Using Tomato Wastes

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OUTLINE

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Which WG Member?

FoodWaStop COST Action CA22134

WG4: Valorisation of agrofood waste and a circular bio-economy

WG6: Networking and dissemination, communication and transfer of knowledge

COST 2515-TUBITAK/Accepted

With Green Agreement we all know that:

- World population is increasing,
- There is an important climate change-temparatures are increasing,
- We need clean water,
- We have limited food sources,

As a result ,

We have to use our resources and wastes very carefully.

- Sustainability,
- Recycling
- **Upscaling,**
- Environment friendly,
- Climate friendly technologies are becaming very important terms

In today's fast-paced digital world, electronic devices have become an unavoidable part of our lives and consumers are demanding for more:

- Very good electronic properties,
- Water proof,
- Flexible,
- Flame reatardant,
- Lightweight,
- Cheap…etc

Multifunctional materials especially for **wearable electronics** becoming very important

These electronic devices, conducing to increasing eielctromagnetic interference (EMI);

- which affect our health badly,
- as well as the sensitivity of miniature electronics.

Developing highly effective multi-functional EMI shielding materials are of great interest and importance.

[2] Namwari M, İnan T., Altan A. 2023.” MXene-cellulose nanofiber composites: toward green, multi-functional, flexible, and highly efficient electromagnetic interference shielding materials”, Graphene and 2D Materials (2023) 8:5–26, https://doi.org/10.1007/s41127-023-00056-4

This technology requires materials;

- having high conductivity,
- permeability,
- permittivity,
- processability,
- corrosion resistance,
- while being cost-effective
- and environmentally friendly.

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LIGNOCELULOSIC BIOMASS ?

Lignocellulosic biomass production areas

Rural	Agriculture, forestry and livestock
Urban	Sewage sludge and municipal solid wastes
Industrial	Cellulose and agri-food industries

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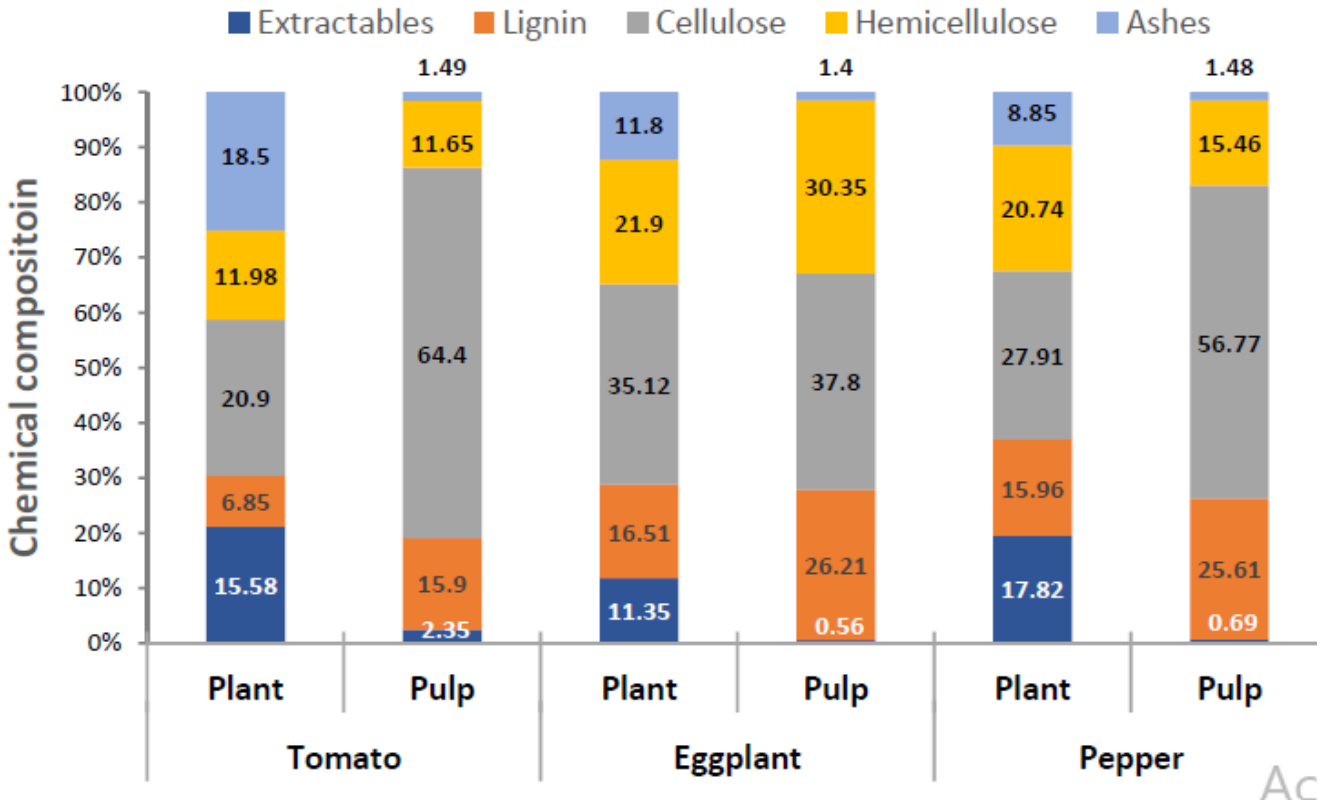
LIGNOCELULOSIC BIOMASS

Lignocellulosic Biomass (per Group)	Cellulose (%)	Hemicellulose (%)	Lignin (%)
Cellulose and paper wastes	76–99	0–13	0–11
Energy crops and agriculture wastes	16–48	19–36	8–25
Animal wastes	5–28	12–21	2–14
Wood	41–54	11–36	16–28

. Chemical composition of horticultural plant residues and cellulosic pulps

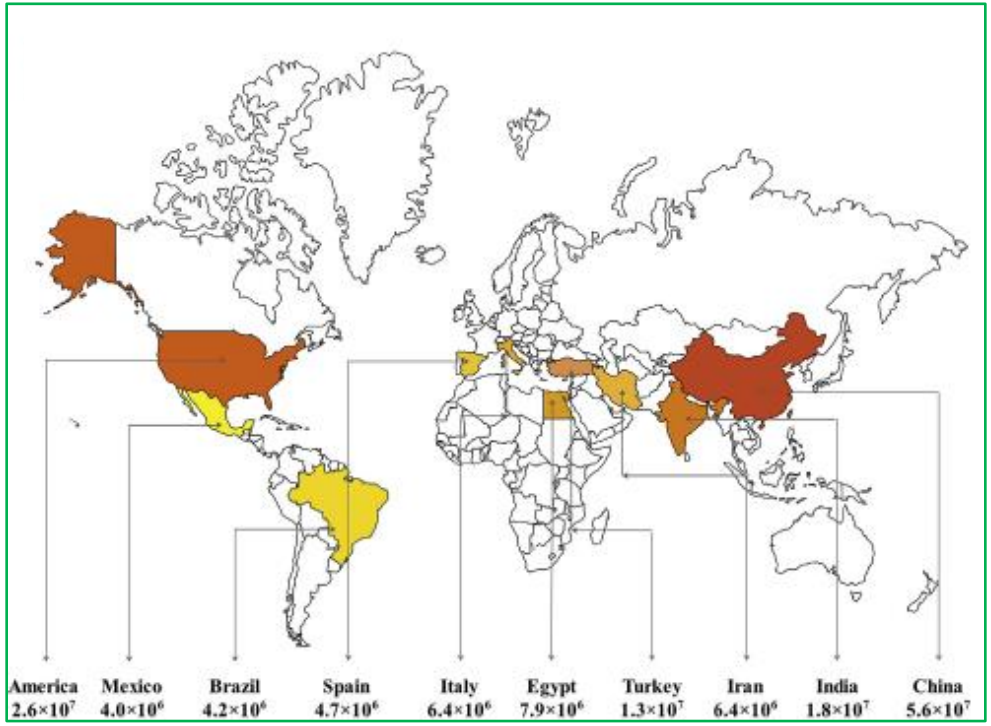


Villegas I. B., Espinosa E, Sánchez R., Tarrés Q., 2020, "Fernando Pérez-Rodríguez and Alejandro Rodríguez, Horticultural Plant Residues as New Source for Lignocellulose Nanofibers Isolation: Application on the Recycling Paperboard Process", Molecules, 25, 3275.

MOTIVATION

Turkey is among the top ten tomato producing countries in the world and has produced 42% tomatoes alone in 2020 (13,2 million tons-the first place in vegetable agriculture) and naturally have important source of tomato wastes.

The first 10 countries leading countries in tomato production in 2016.



Lu Z., Wanga J., Gao R., Ye F., Zhao G., 2019. Sustainable valorisation of tomato pomace: A comprehensive review, Trends in Food Science & Technology 86, 172–187.

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PROJECT SUMMARY

There is a need to work towards producing value-added products using agricultural wastes since . It is among the priority issues in all the UN and EU strategy documents globally and in the 11th National Development Plan.

Proximate composition of tomato pomace and its peel and seed fractions.

Material	Chemical composition (g/100 g dw)				
	Lycopene × 10^3	Fiber	Protein	Ash	Oil
Peel	nr[a]	78.56	10.50	5.90	4.04
Peel	nr	87.61–88.53	6.00–6.20	2.03–2.25	nr
Peel	nr	74.46–76.67	11.02–11.13	4.92–6.46	4.94–5.50
Peel	nr	62.79–69.94	0.99–1.85	1.04–3.26	1.63–1.99
Peel	nr	nr	23.26	3.97–4.18	3.54–6.22
Peel	13.59	nr	nr	nr	nr
Peel	7.36	nr	nr	nr	nr
Peel	288	nr	10.08	25.64	3.22
Seed	nr	16.00	32.00	5.00	22.00
Seed	nr	nr	27.24	3.37	17.80
Seed	nr	nr	39.72	4.68–5.33	22.20–22.74
Seed	nr	nr	23.60	3.64	24.50
Seed	nr	nr	35.02–40.94	nr	19.84–23.44
Pomace	nr	59.03	19.27	3.92	5.85
Pomace	nr	39.11	24.67	5.29	9.87
Pomace	9.82–17.21	58.53–68.04	15.08–22.70	2.88–4.40	8.37–16.24
Pomace	nr	46.00	16.00	4.00	2.00

[a] nr refers to not reported.

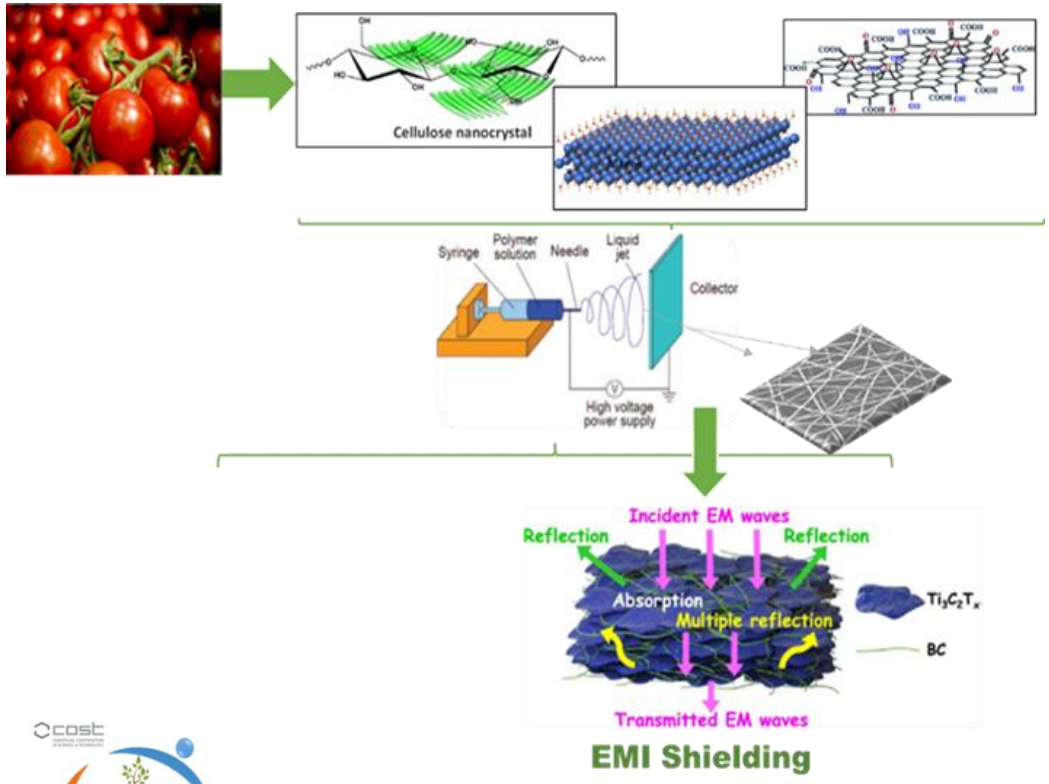
Nanocellulose production

Nanocellulose Product	Diameter, nm	Length, nm
Cellulose nanofibers (CNF) Microfibril	2–10	>10,000
Cellulose nanocrystals (CNC)	2–20	100–600
Bacterial nanocellulose (BNC)	4–10	100–2000
Cellulose nanofibers (CNF) Microfibrillated	10–40	>1000
Microcrytalline cellulose (MCC)	>1000	>1000

Mateo S., Peinado S., Morillas-Gutiérrez F., Dolores La Rubia M., Moya A. J., 2021. "Nanocellulose from Agricultural Wastes: Products and Applications—A Review", Processes, 9, 1594. https://doi.org/10.3390/pr9091594

PROJECT SUMMARY

- Lignocellulosic components will be extracted from tomatoes wastes using Acidic Deep Eutectic Solvents (ADES) and low energy methods of Microwave (MW), Ultrasound (US) and if needed mechanical methods.
- MXene preparation-delamination and characterization,
- Electrospun, MXene containing multi-functional composites will be used to prepare multifunctional EMI shielding materials to protect devices in the whole X-band range (8-12 GHz).



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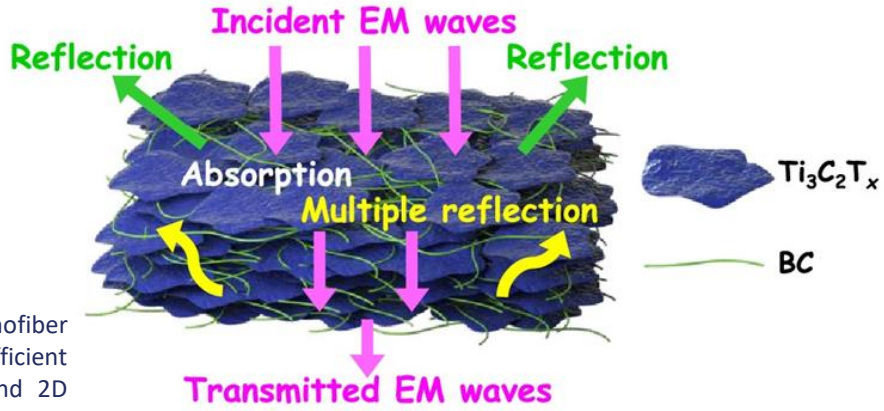
The electromagnetic wave (EMW) attenuation occurs through 3 mechanisms;

- **The primary one** is **reflection. Metalic materials are used.** However, they suffer from high density, low wear or scratch resistance, corrosion susceptibility, and high cost.
- **The secondary** mechanism is **absorption** with high dielectric constant such as ZnO, SiO_2, TiO_2, and $PbTiO_3$, $BaTiO_3$ or high magnetic permeability, like carbonyl iron, Ni, Co, or Fe metals, γ-Fe_2O_3, or Fe_3O_4. Narrow-band action, and processing difficulties hinders their application for EMI shielding.



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- **Multiple reflections** is the **third mechanism** that occurs at vari surfaces or interfaces. The scattering effect of inhomogeneity, large interfacial area and porosity enhance this incident which exists in composites, foams, and honeycomb structures.

- **Intrinsic conductive polymers** (polyacetylene, polythiophene, polypyrrole (PPy), and polyaniline (PANI) are EMI shielding but their **rigid structure** leads to **poor processability**.

- Carbon-based materials (C black, C fibers, carbon nanotubes (CNTs), and graphene have been tremendously used in EMI shielding due to their high mechanical, electrical, corrosion resistance, and lightweight properties but in **large quantities**.

MOTIVATION

- To conquer the above-mentioned hurdles, the development of materials with **low thickness**, **lightweight**, **high conductivity**, **processability**, **sustainability**, **strong attenuation**, and **cost-competitiveness** has received tremendous attention.

- **MXene-based** composites are representative examples of material with large specific surface areas, light weight, easy processability, high electrical and thermal conductivity as **a promising candidate** for EMI shielding.

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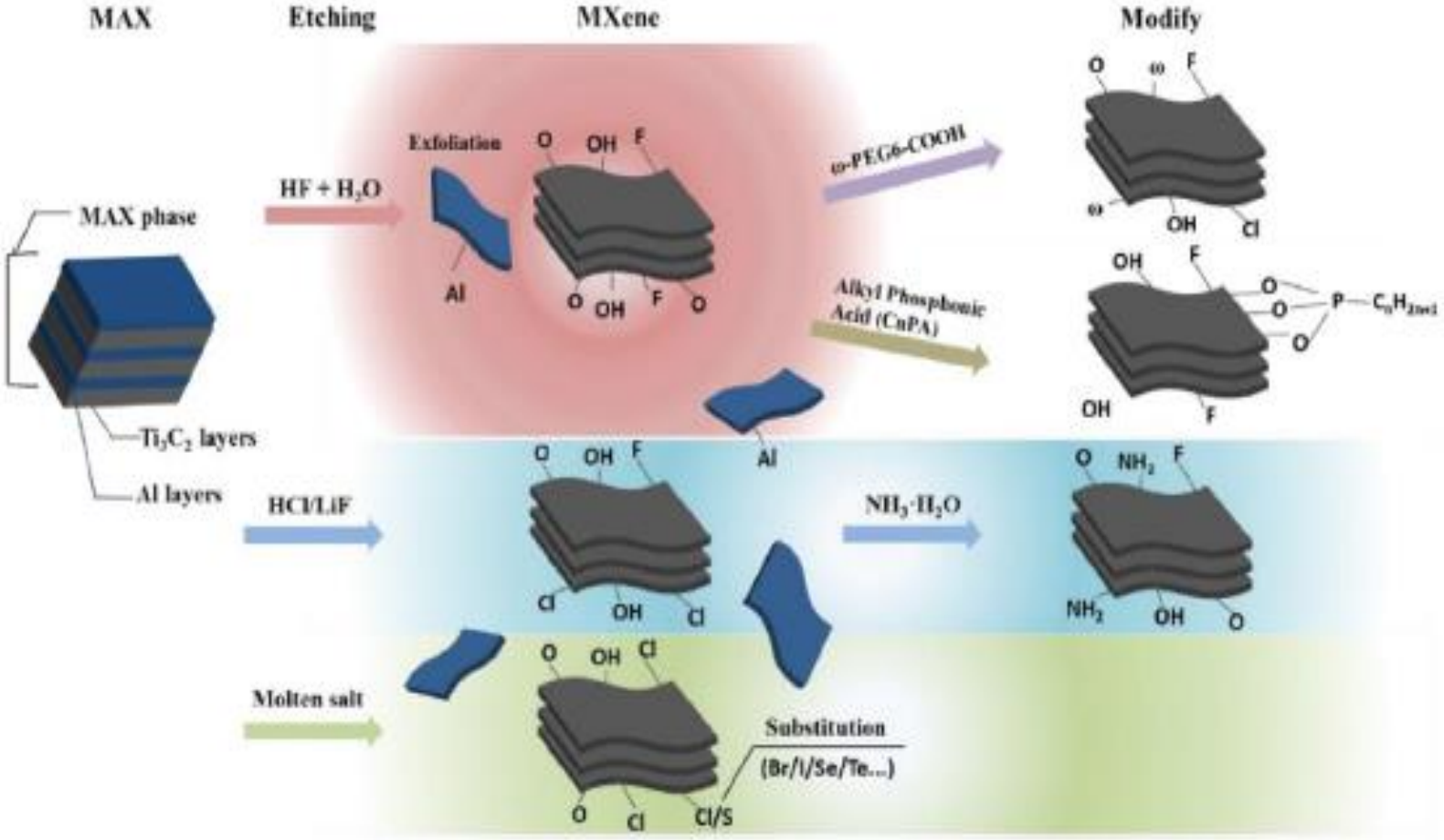
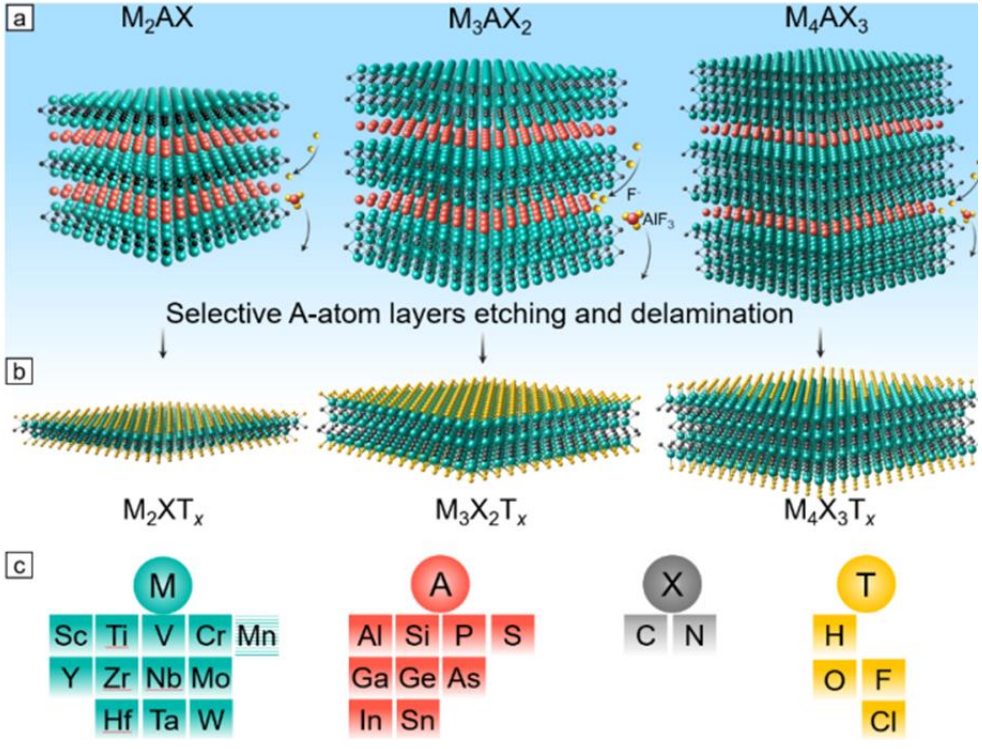
MXENES


MAX
Etching
MXene
Modify
MAX phase
Ti_3C_2 layers
Al layers
HF + H_2O
Exfoliation
Al
ω-PEG6-COOH
Alkyl Phosphonic Acid (CnPA)
HCl/LiF
$NH_3 \cdot H_2O$
Molten salt
Substitution
(Br/I/Se/Te...)

MXENES



- MXenes are a class of 2D transition metal carbides, nitrides, and carbonitrides primarily synthesized from $Mn^{+1}AXn$ (MAX) precursor materials where M is an early transition metal (Sc, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, etc.), A represents Al, Si, Ga, etc., X is C and/or N, and n = 1–4.
- MXenes were introduced in 2011 by Drexel University scientists [38], with a general formula of $Mn^{+1}X_nT_x$, where T_x represents the surface functional groups, typically –O,–OH,–F, and/or –Cl.
- MXene can be scalably synthesized by selective etching of Al using acid and salt mixtures, including pure hydrofluoric acid (HF), HCl + LiF (forming HF in situ), HF+H.

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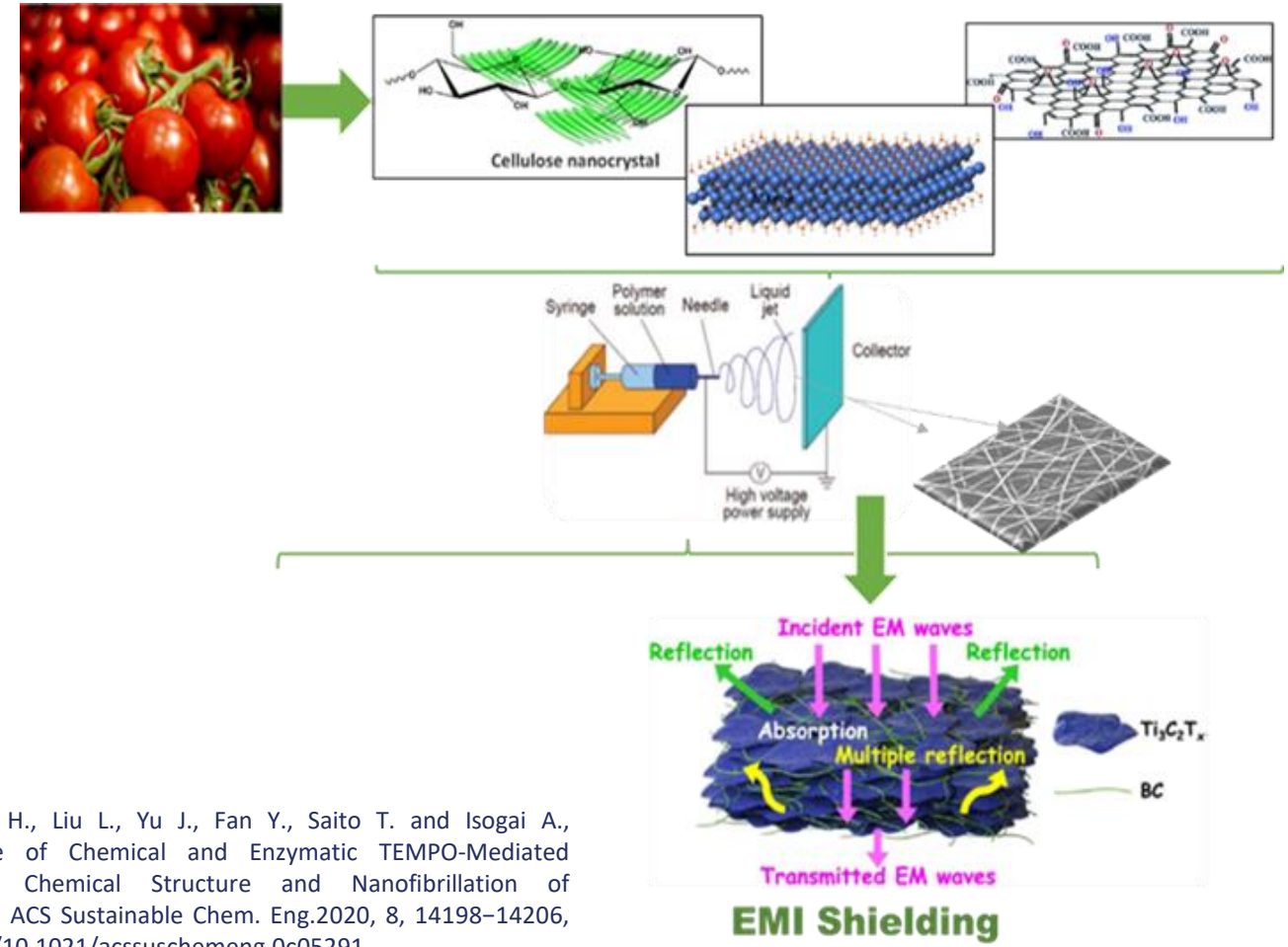
DES (Deep Eutectic Solvents)

The DES solvents are mixtures with hydrogen bond donors (HBD) and hydrogen bond acceptors (HBA).Due to the high synthesis costs and recycling problems of existing solvents and ionic liquids (ILs), a new class of eutectic mixtures of DES having properties of ILs but cheaper and easily recyclable will be used.

PROJECT SUMMARY



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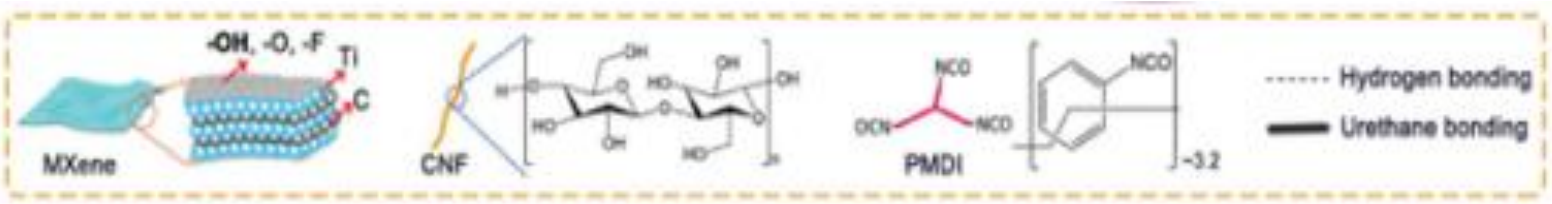

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Thank you for your attention and for your patience!

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