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Acid modified MXenes for catalytic PET depolymerization

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Motivation & Objectives

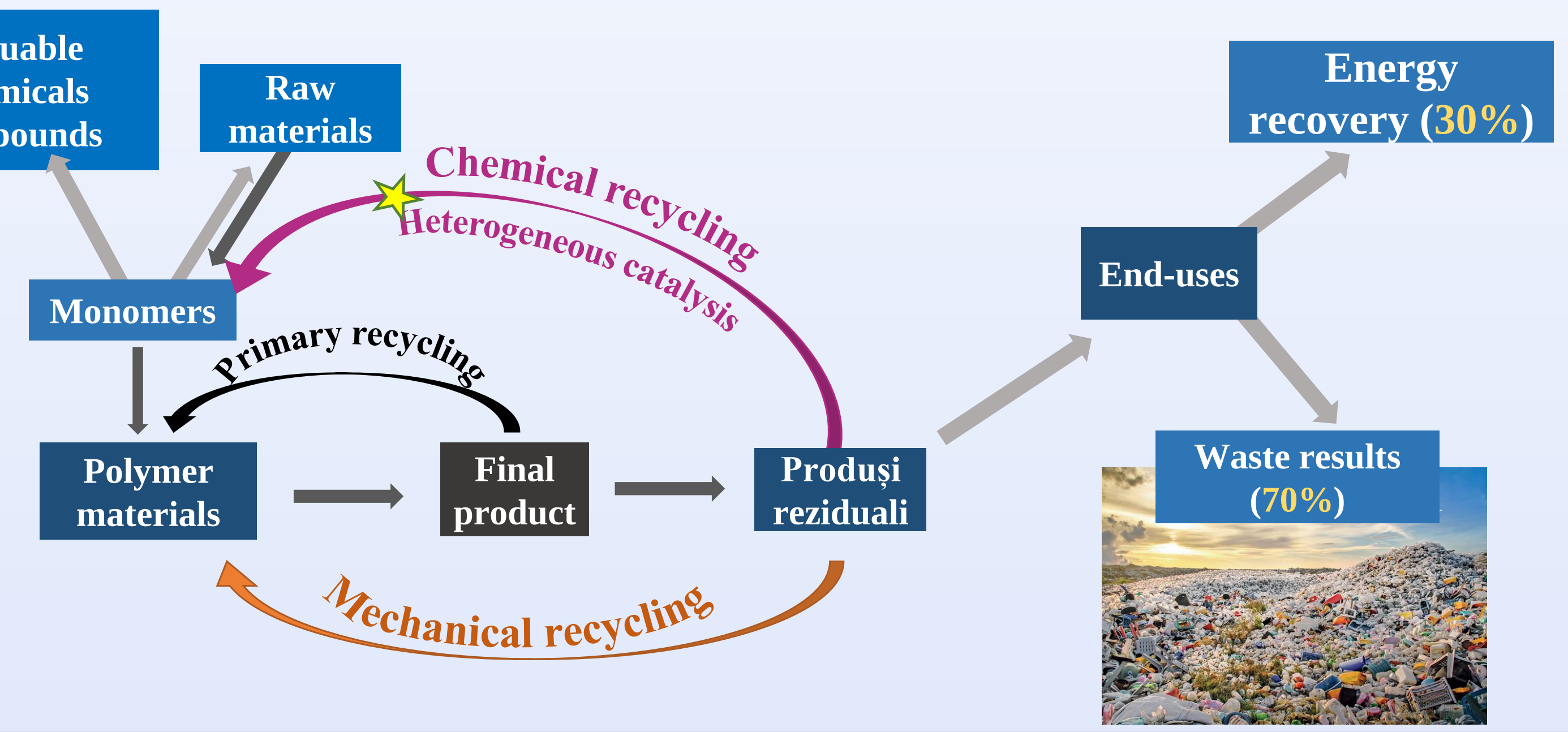
Plastics - a challenge for society? How?

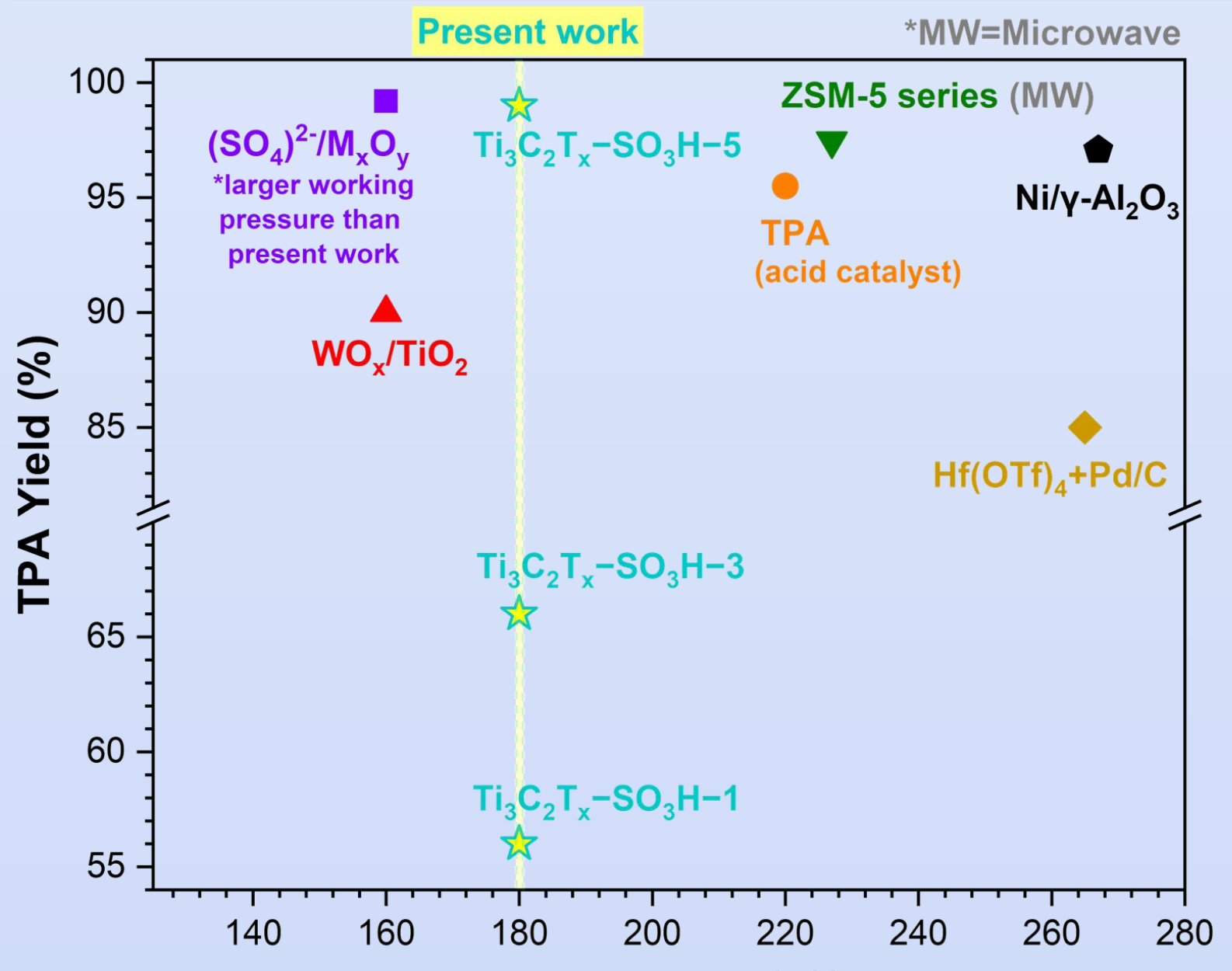
High consumption

Large quantities of plastic waste

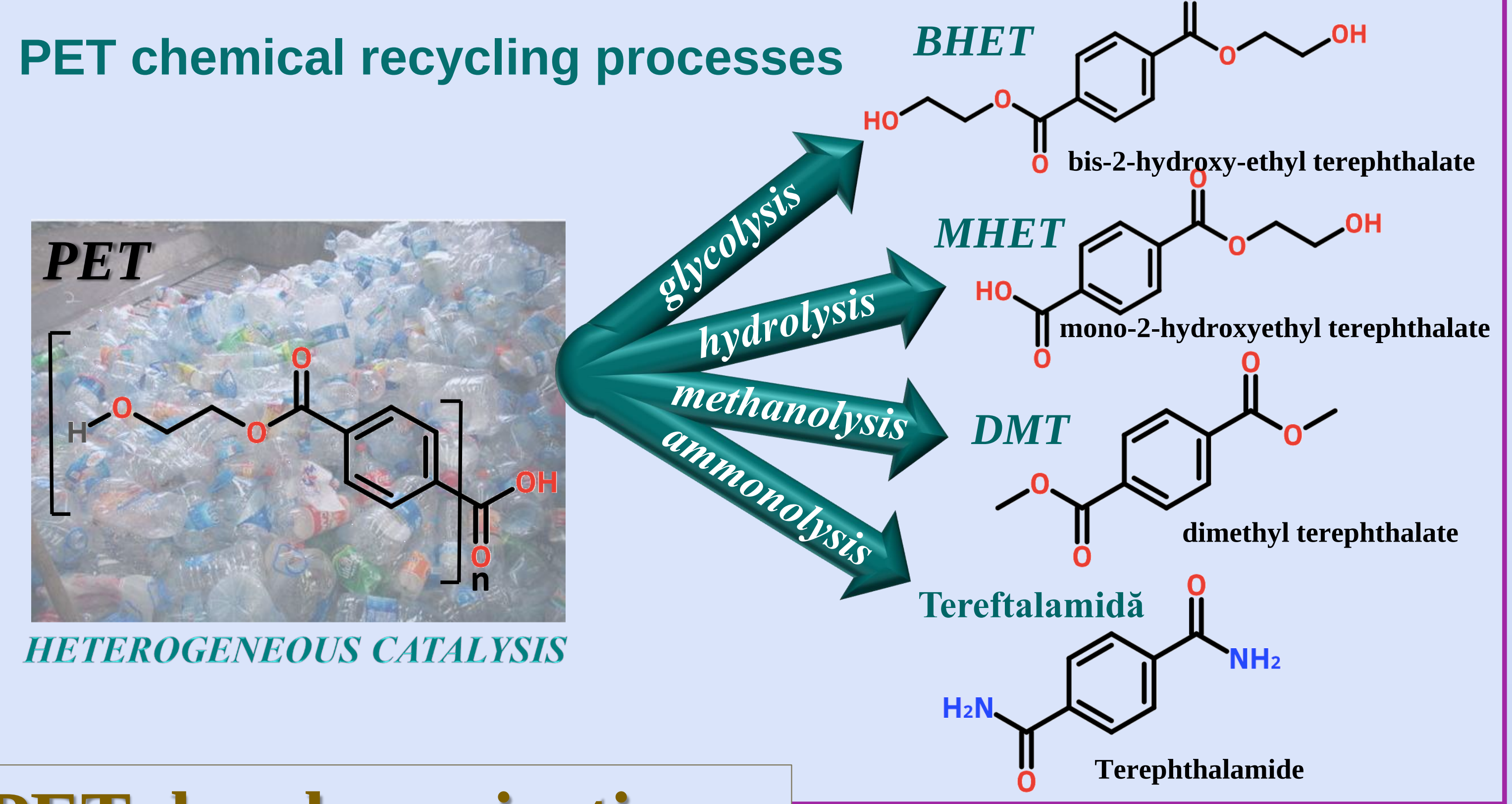
Bad plastic waste management!

Crisis situation





PET chemical recycling processes



Context of PET depolymerization

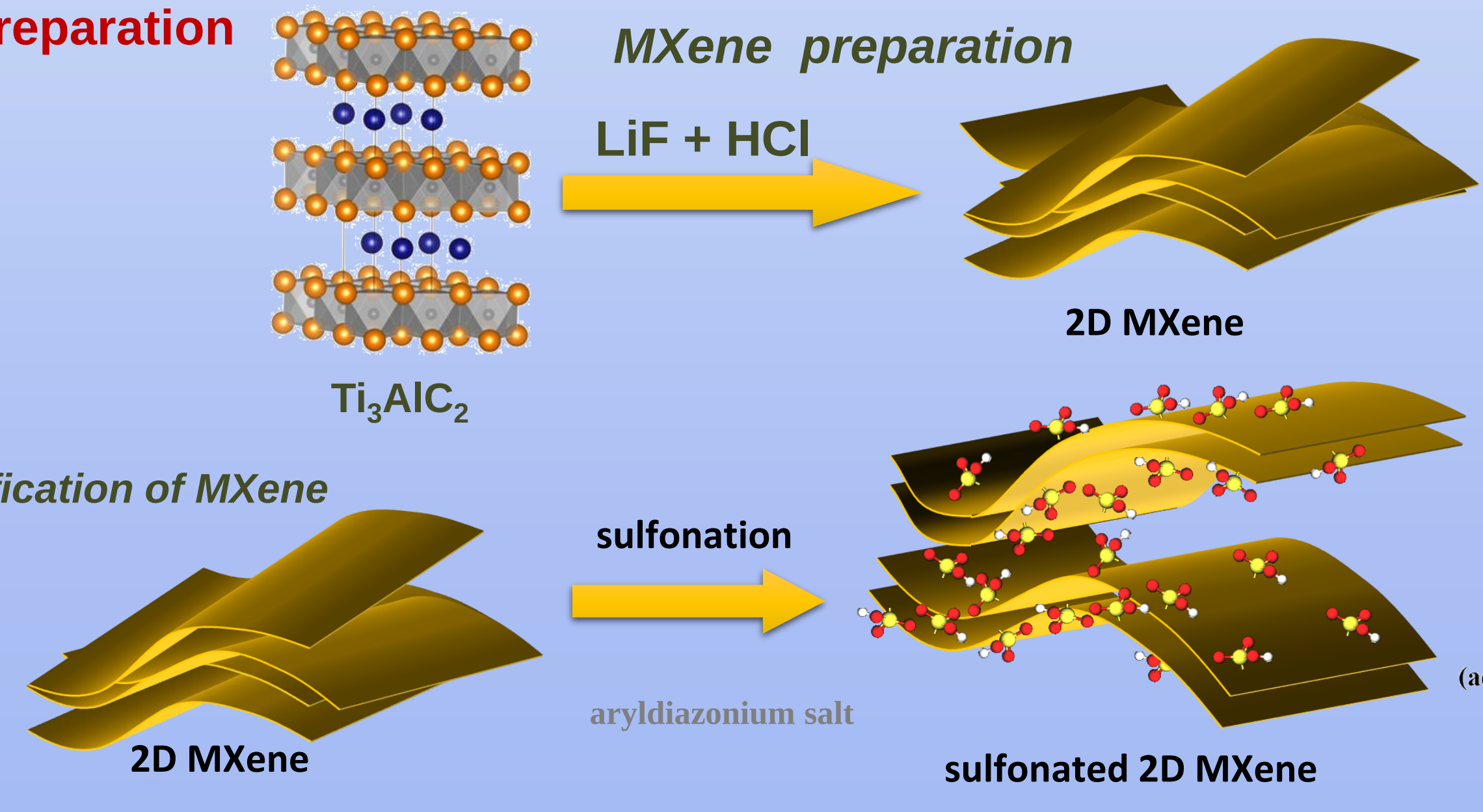
Depolymerization is an acid-catalysed process → Strong acid cites

LIMITATIONS of heterogeneous catalytic systems: → – medium-high acidity ↗ temperature

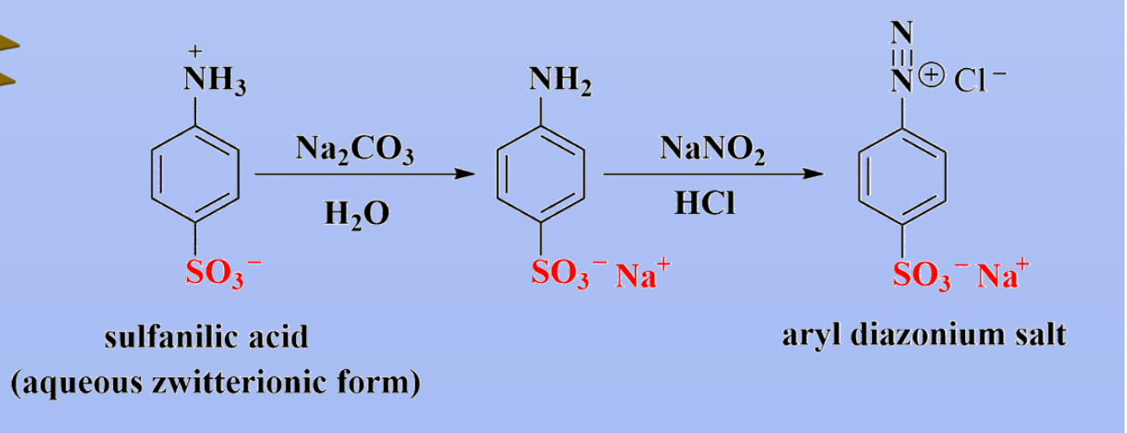
– microporous structure ↘ accessibility

SOLUTION: a material with strong, stable and accessible acid centers to enable depolymerization at lower temperatures and higher reaction rates.

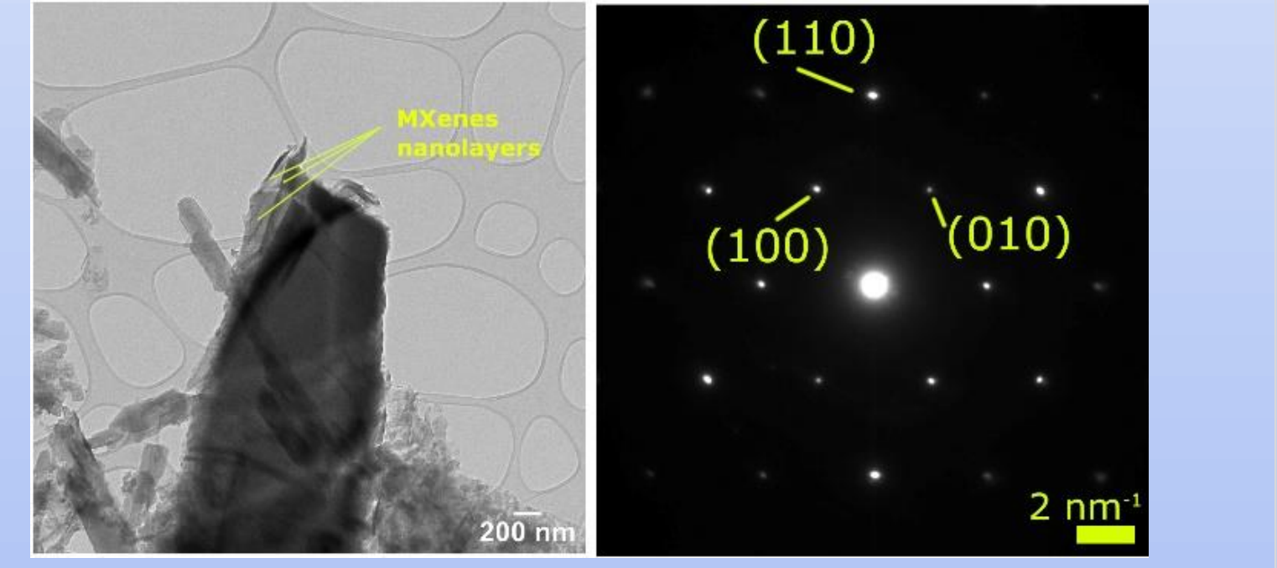
Catalyst preparation



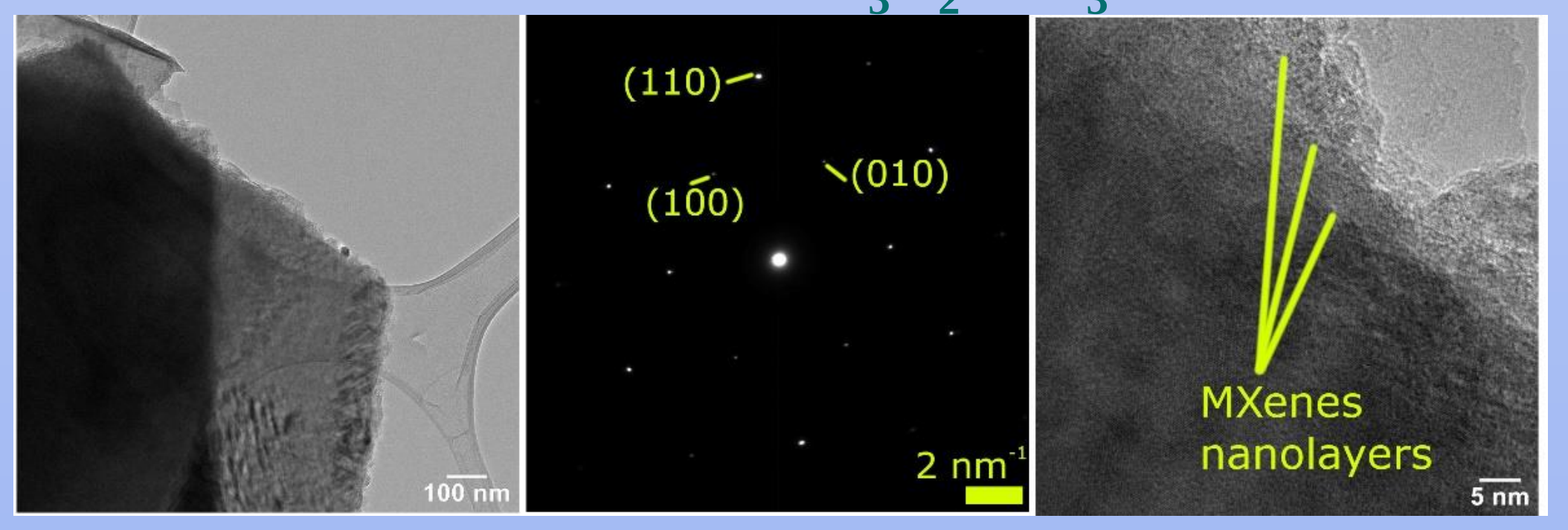
CATALYST	Ti (%)		C (%)		O (%)		N (%)		S (%)	
	SEM	TEM	SEM	TEM	SEM	TEM	SEM	TEM	SEM	TEM
Ti_3AlC_2		40.8		40.2		4.0	-	-	-	-
$Ti_3C_2T_x$	67.4	36.0	12.1	48.8	20.6	15.2	-		-	
$Ti_3C_2T_x$-SO_3H	51.7	45.0	16.6	44.2	26.7	10.6	0.6	-	4.4	0.02



Ti_3C_2 (MXene)



Ti_3C_2–SO_3H



Results & Discussion

Catalytic reaction – Experimental part:

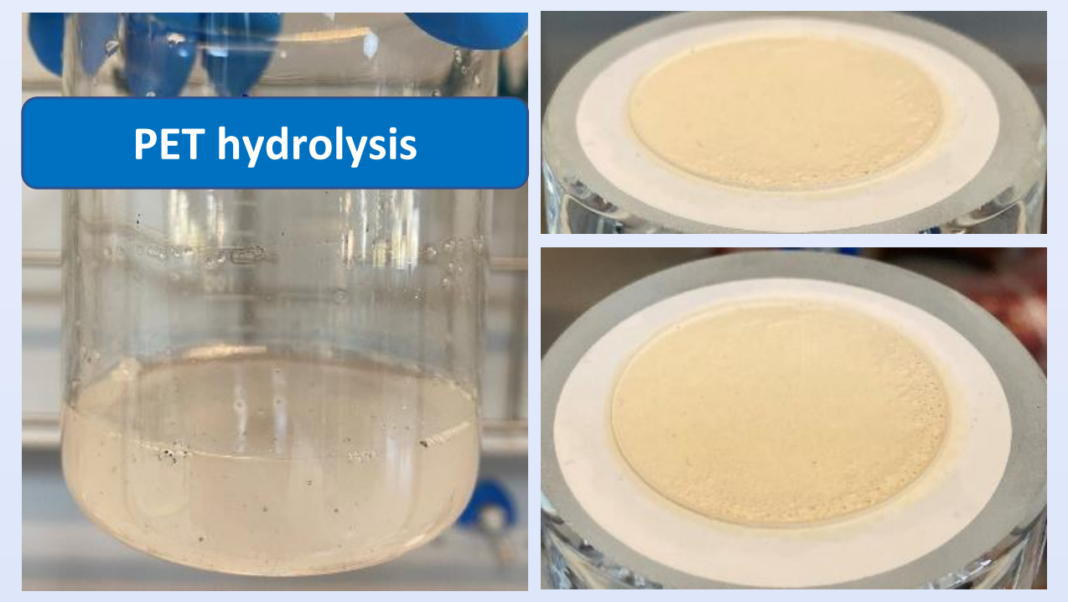
Reaction conditions

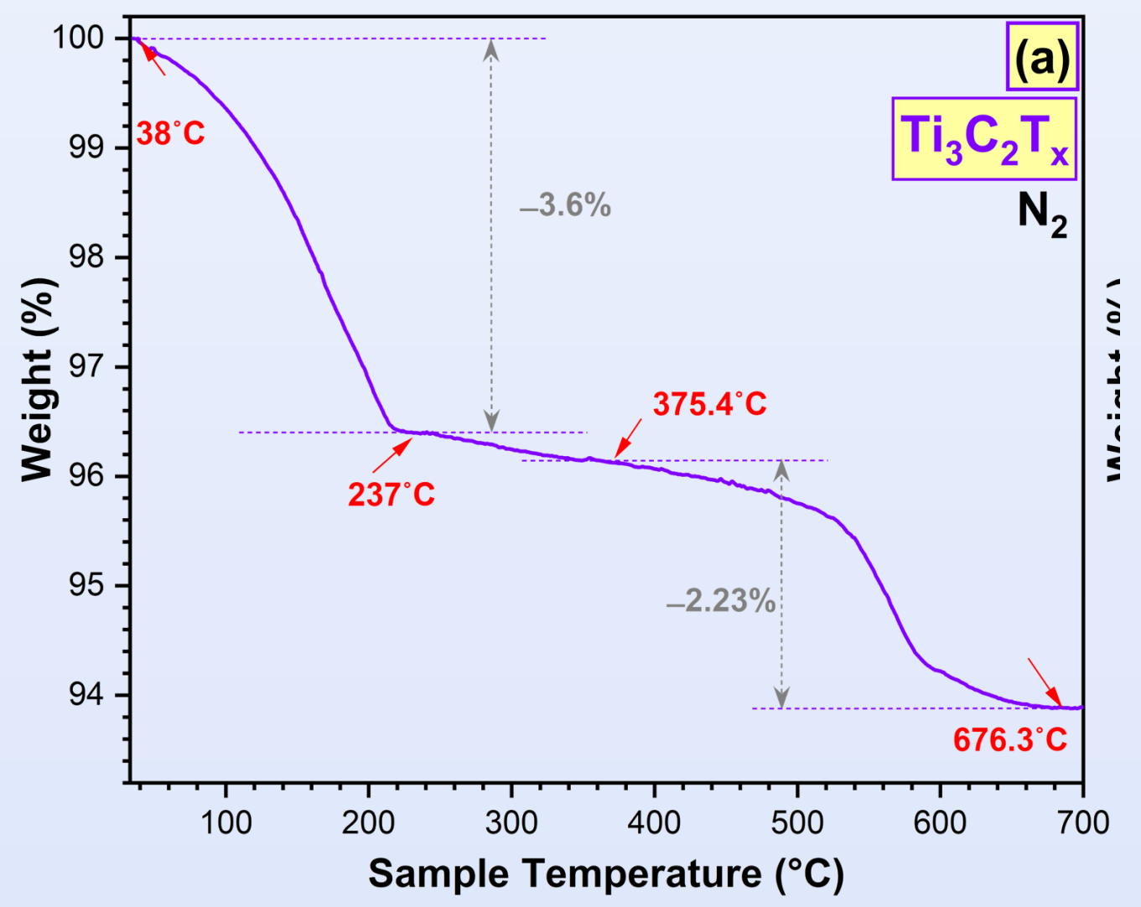
- ✓ *Reaction temperature* (160-180 °C)
- ✓ *Reaction pressure* (10 bars N_2)
- ✓ *PET* (100 mg) –chips 3x2 mm
- ✓ *Catalyst* (20-60 mg)
- ✓ *Reaction time* (24h)
- ✓ *Solvent:* H_2O

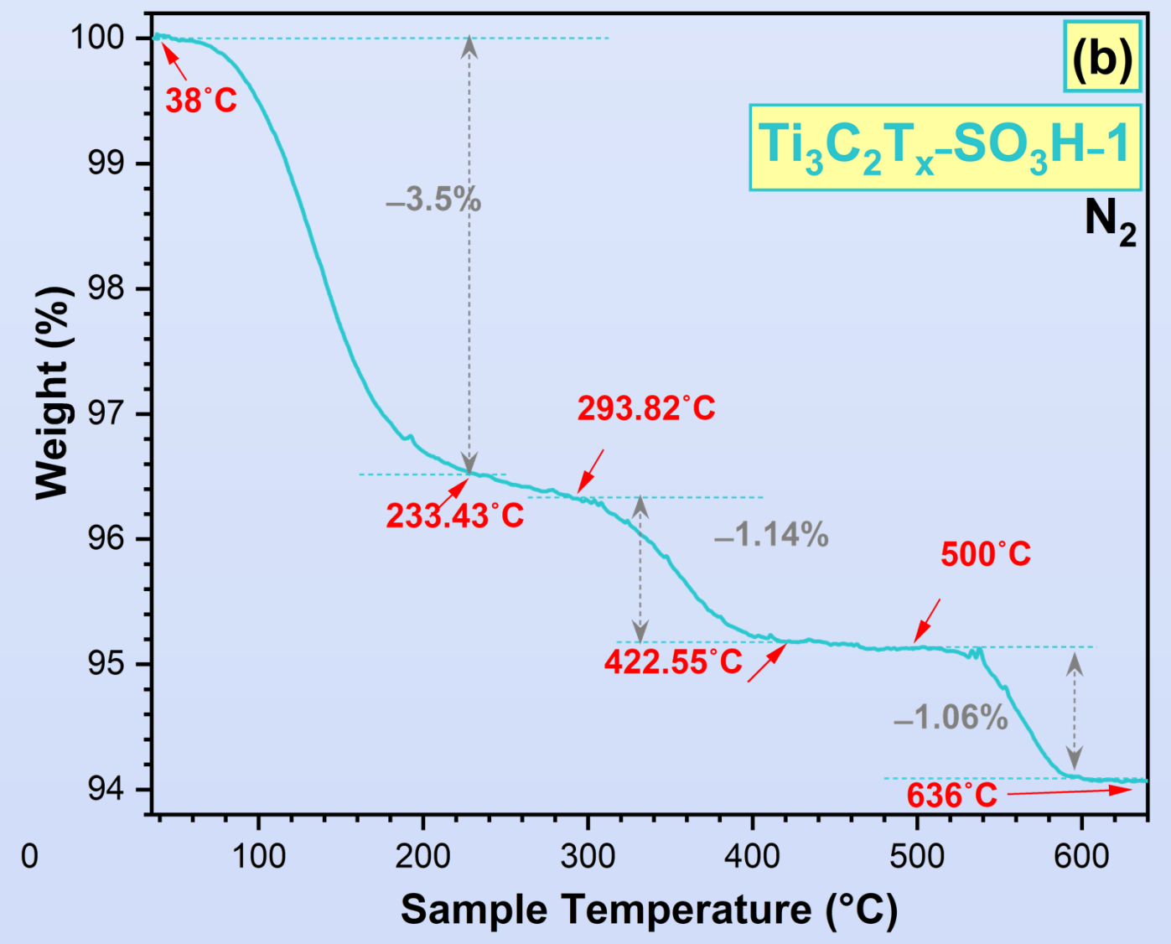
*TPA = terephthalic acid

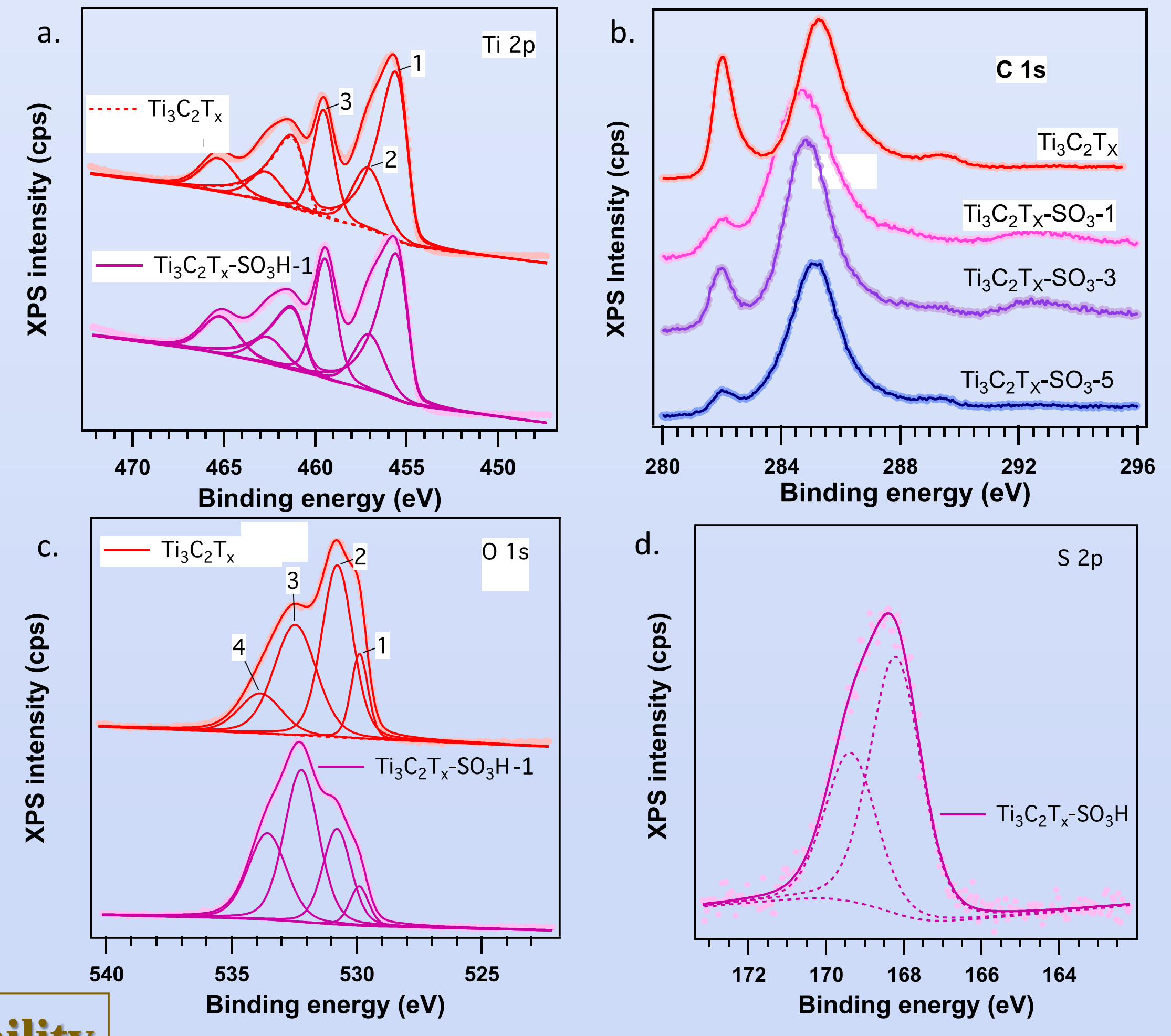
Post-treatment

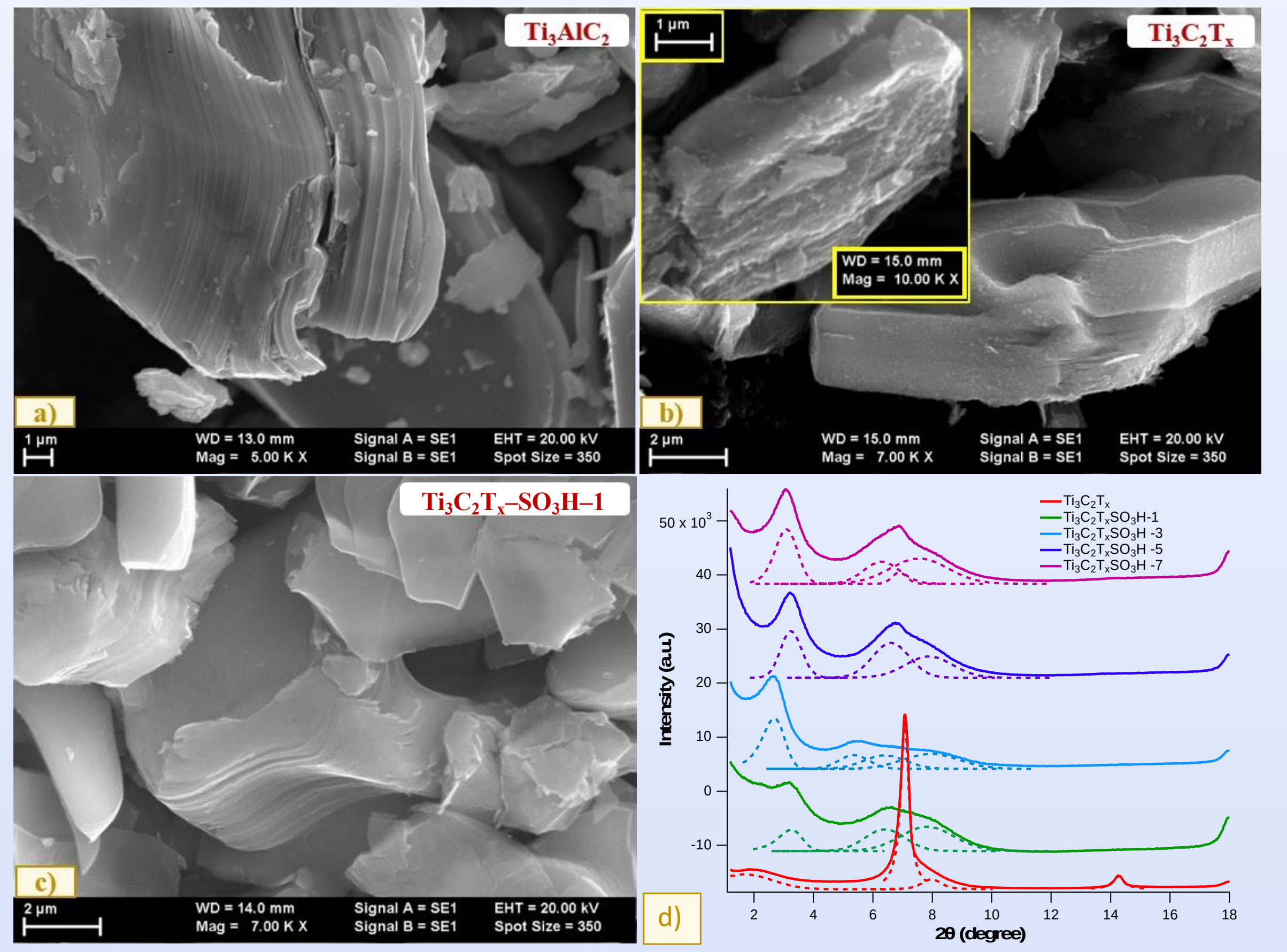
- ✓ Addition of 1M NaOH solution to
- ✓ form TPA-Na^+
- ✓ Filtration
- ✓ Precipitation of TPA* with HCl

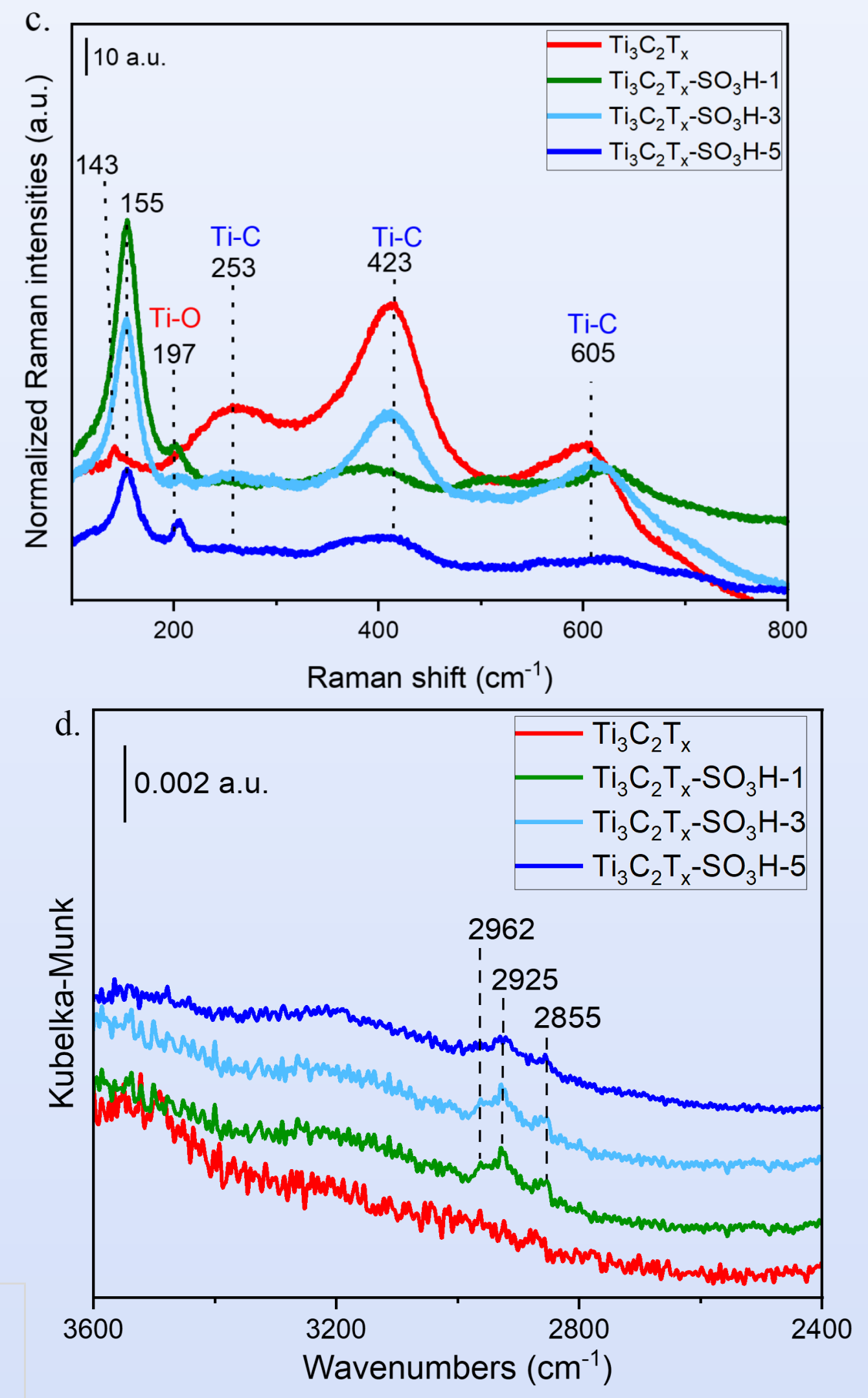




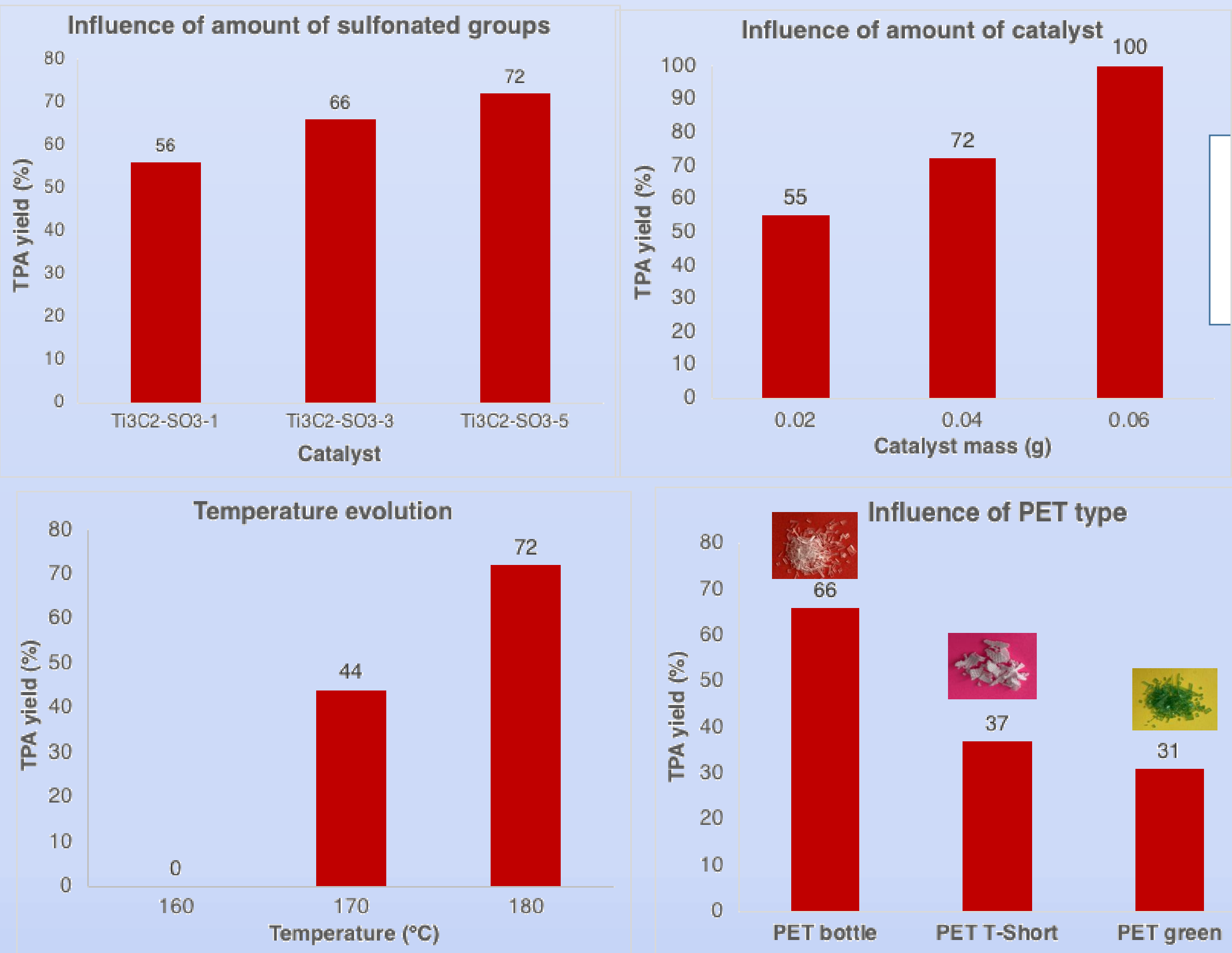


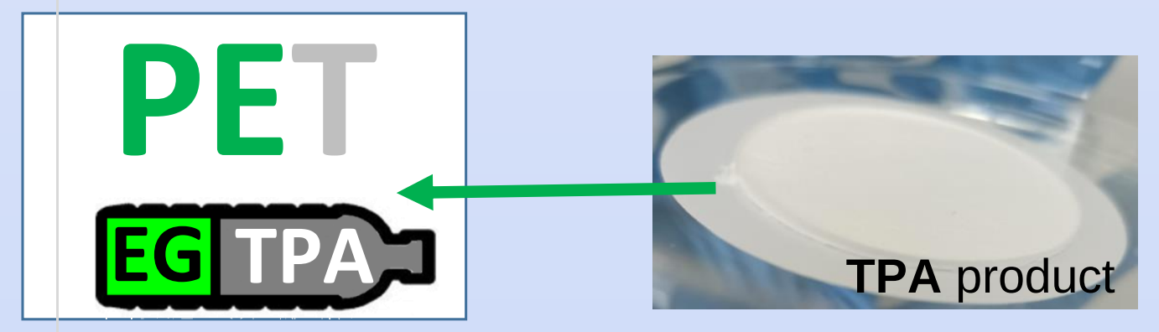


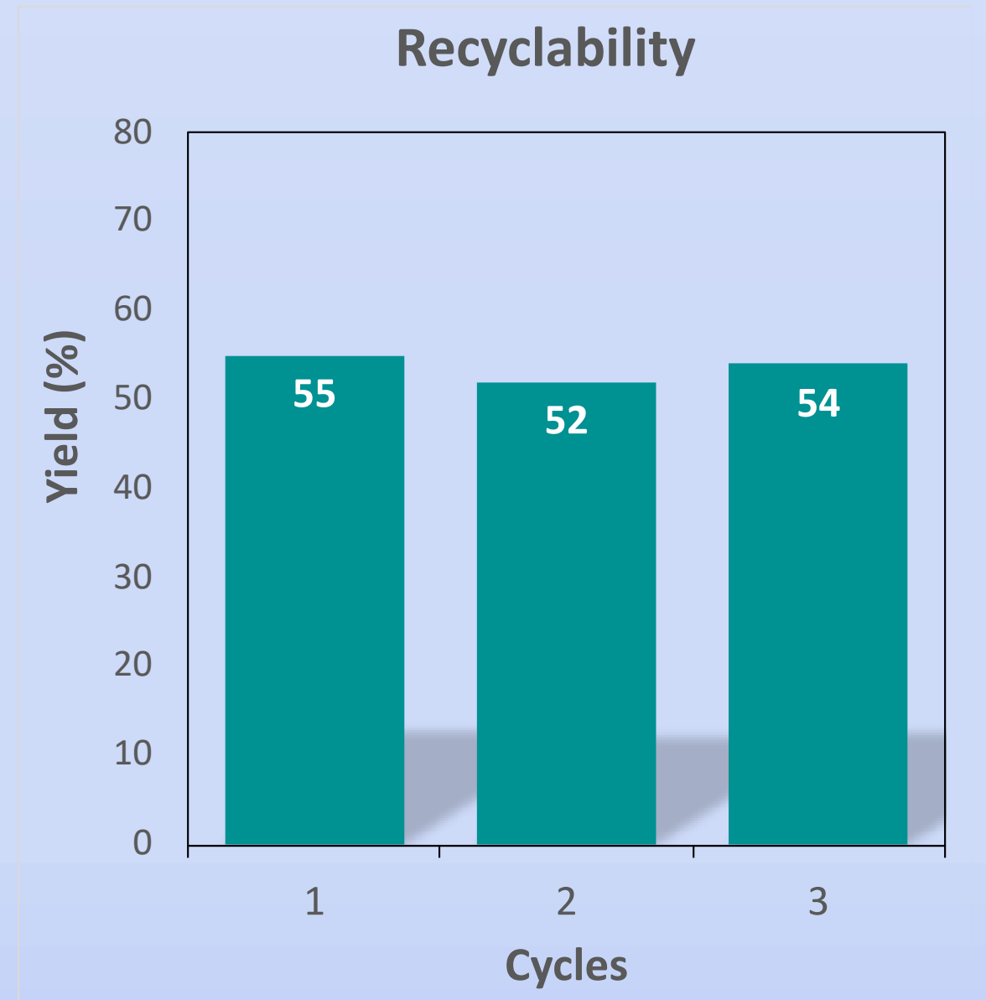




Catalytic reaction - Results







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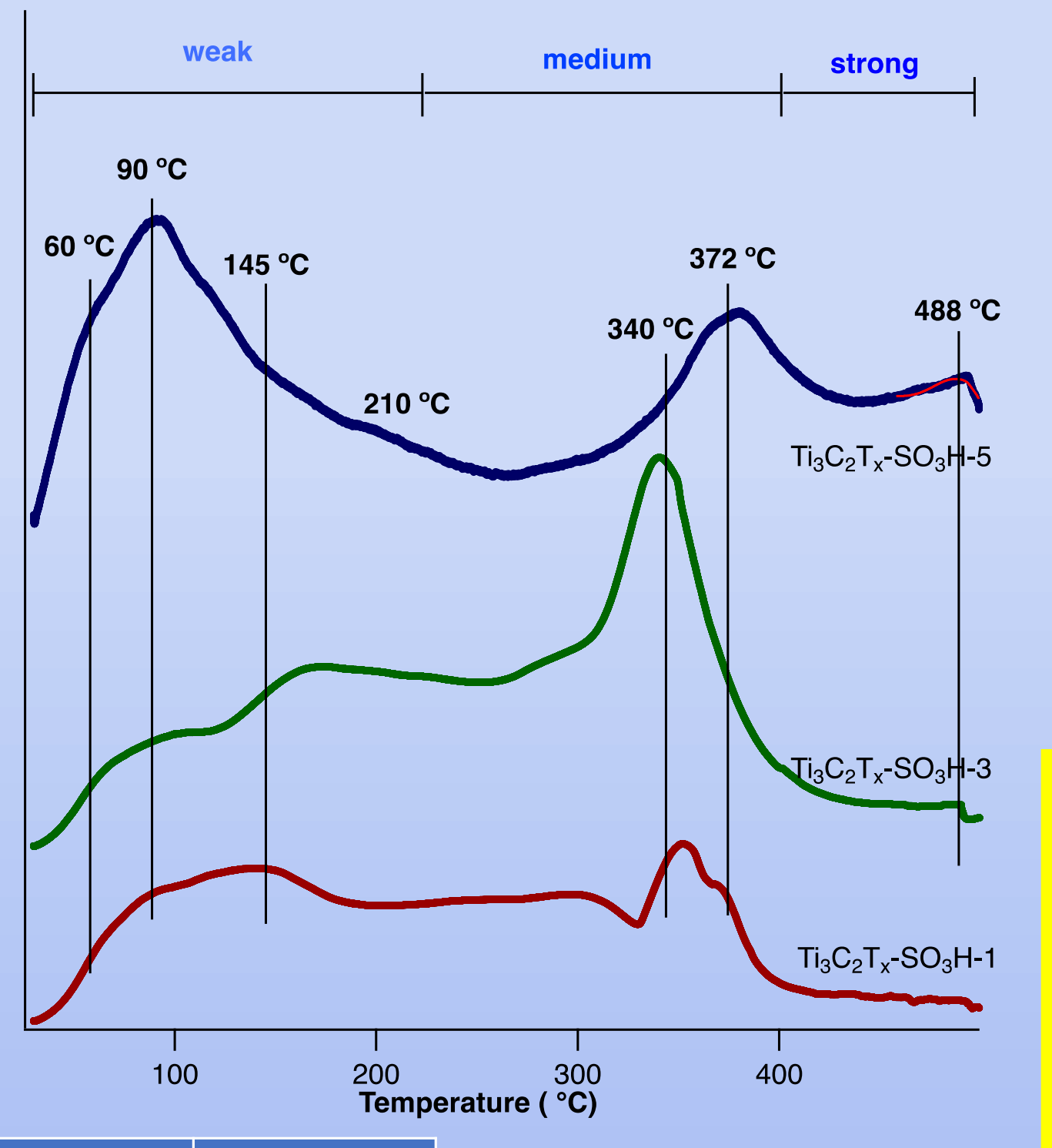

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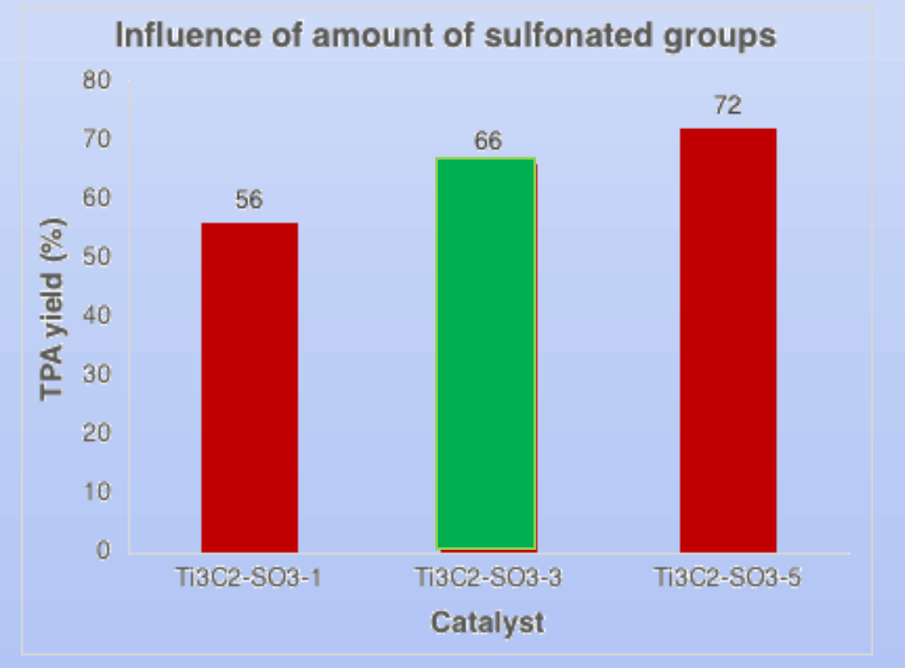

180 °C; 40 mg catalyst

ACIDITY	$Ti_3C_2T_x$-SO_3-1	$Ti_3C_2T_x$-SO_3-3	$Ti_3C_2T_x$-SO_3-5
	(mmol/g)		
weak	964	734	2841
medium	644	1452	704
strong	-	-	77
Total	1608	2186	3622

ACS Sustainable Chem. Eng. 2024, 12, 9766−9776.

Conclusions

- ✓ Using aryl diazonium salt is a good approach to modify MXene with –SO3H groups on its surface.
- ✓ These materials are efficient in the PET depolymerization.
- ✓ The amount of sulfonic groups influence the yield of TPA.
- ✓ A higher temperature leads to a higher TPA yield.
- ✓ These materials are efficient for different types of PET. However, additives in PET influence negatively the depolymerization.

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