Photochemical Up-cycling Of Polystyrene Waste Using Acridinium Salts

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CONTEXT

Plastic waste recycling is a significant **matter**

→ Majority of plastic waste is **burned/landfilled.**[1]

→ **Only 1%** of recycled plastics are **chemically recycled.**[1]

Chemical recycling of C-C backbone polymers is **challenging** because of their intrinsic stability.

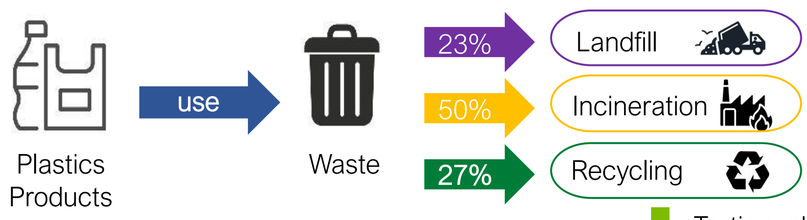
→ **Polystyrene** (PS): - inert, durable, low-cost

- 5th **most used plastic** (20 million tonnes produced/ year).[1]

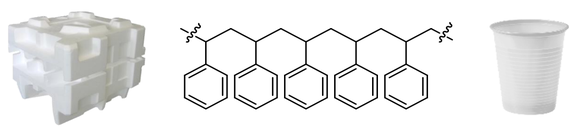
Emergence (over the last 3 years) of **photocatalytic processes** to up-cycle PS into valuable products using light to combine high reactivity and selectivity.[2-3]

Aim: New **selective photocatalytic pathway** to **valorize PS** into high yielded products.

(400.3 Mt in 2022)



Polystyrene (PS) - $28,5 billion in 2021 produced



- More selective process
- Economically attractive

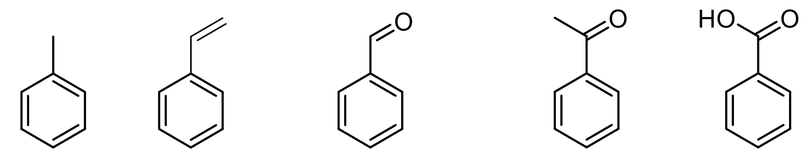
CHEMICAL PS ELIMINATION

Approaches to **chemically** up-cycle PS

- Non-selective processes
- Distribution of several products
- Energy-consuming

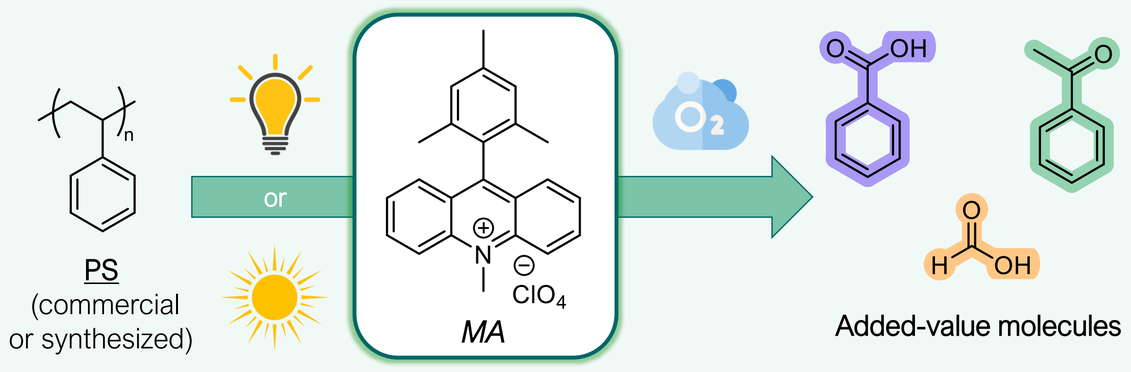
Pyrolysis (500-950°C) | Photocatalysis[4-6] | Electrochemistry | OrganoMet

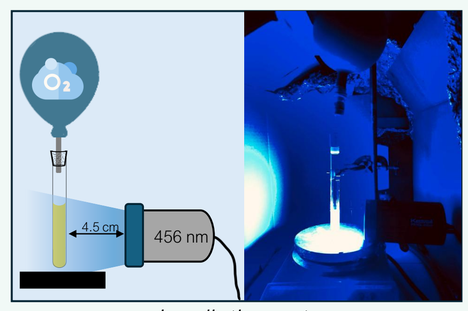
Reaction products:



OUR STRATEGY

- **New selective pathway**[7-8] to photodegrade PS, using **Fukuzumi's catalyst,** 9-mesityl-10-methylacridinium perchlorate (*MA*)
- Working under **mild conditions**

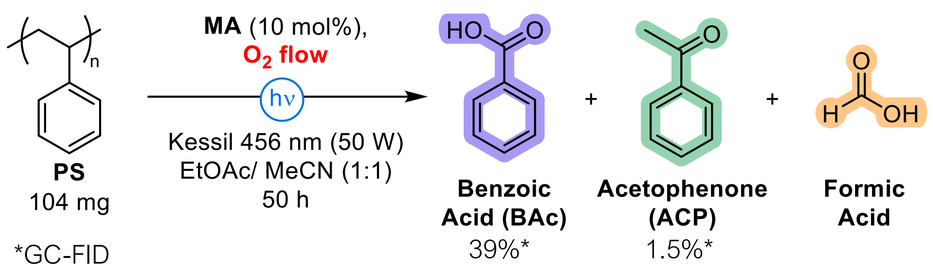


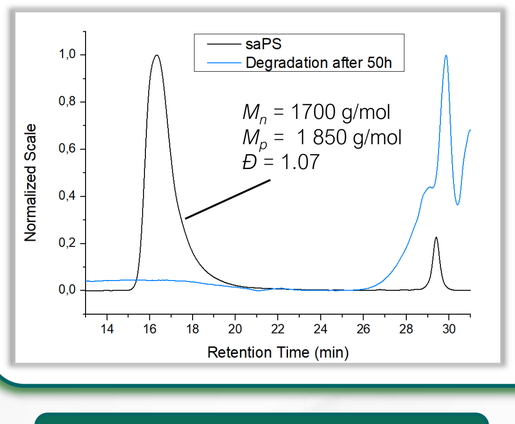


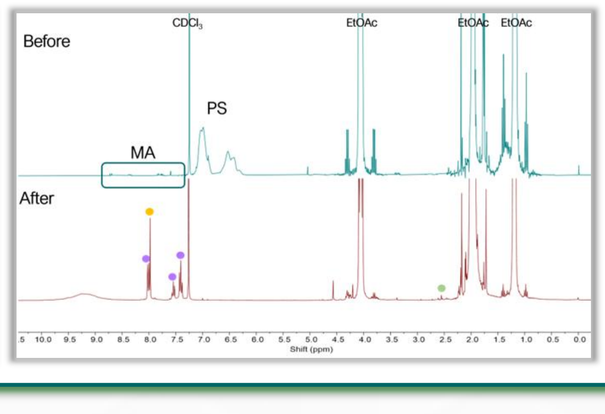
Irradiation set-up

RESULTS

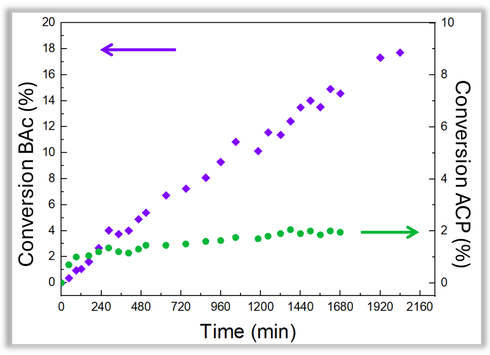
Study of the degradation of PS[8]

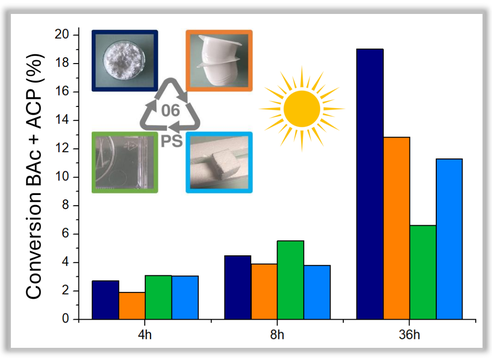




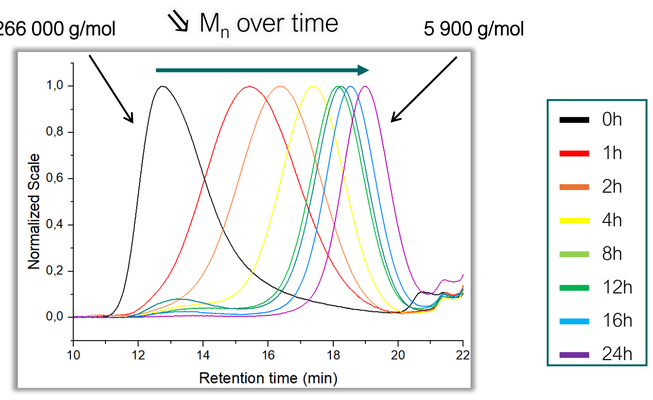


Kinetic study[8]





266 000 g/mol ↘ M_n over time 5 900 g/mol

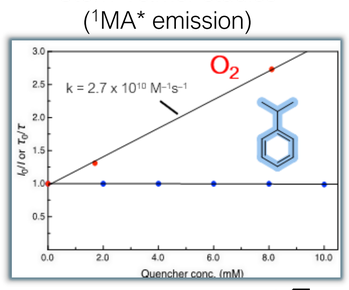


Efficient degradation of PS waste using sunlight

- No interference of additives in **PS** waste
- Short irradiation times: similar degradation for all plastics
- Longer irradiation times: lower conversion for EPS and clearPS

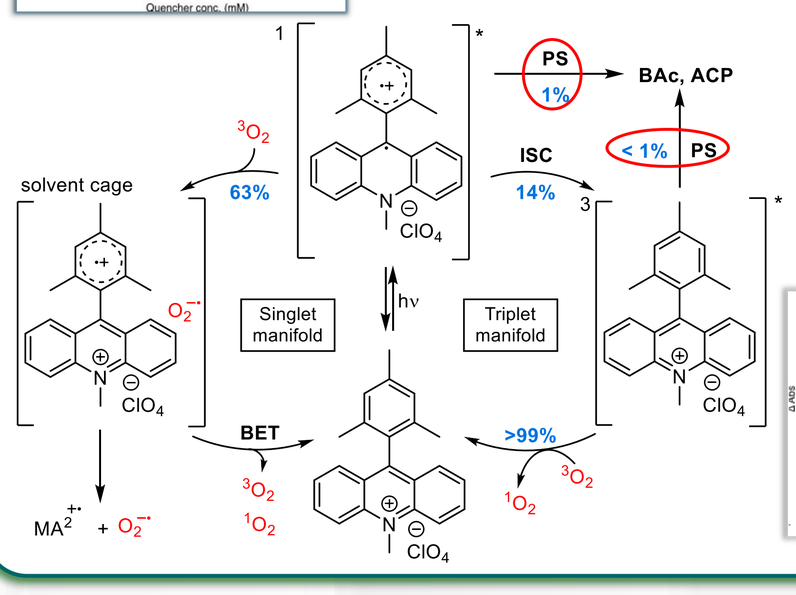
PROPOSED MECHANISM

Stern-Volmer studies
(^{1}MA* emission)

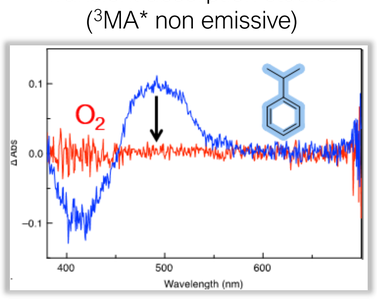


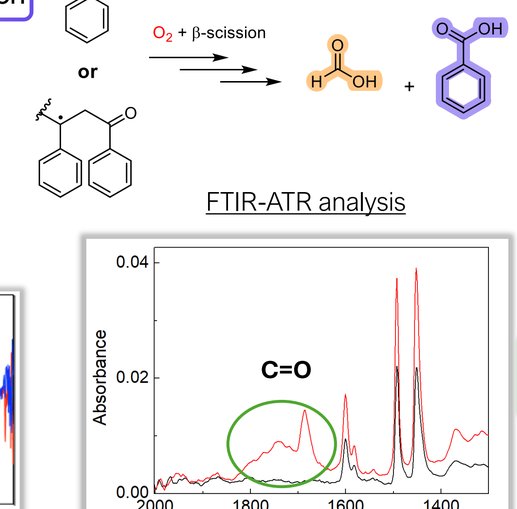
Conclusion:

- Generation of ROS by MA
- No direct reaction between MA and PS but direct HAT on PS with ROS



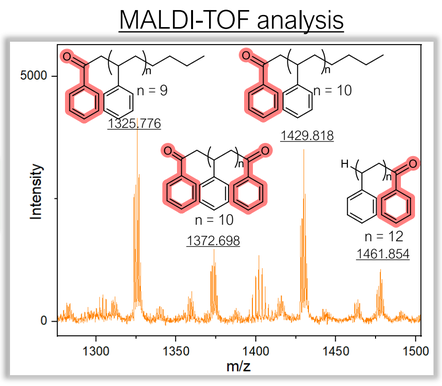
Transient absorption studies
(^{3}MA* non emissive)





FTIR-ATR analysis

MALDI-TOF analysis



Oxygenated PS oligomers

CONCLUSION

- ✓ Efficient way to degrade **PS** (whatever the size)
- ✓ Major products formed = benzoic acid, acetophenone, formic acid
- ✓ Working under visible light
- ✓ Low catalytic charge
- ✓ Turning waste into a resource

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