



# Promising organic flow batteries

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## Main building



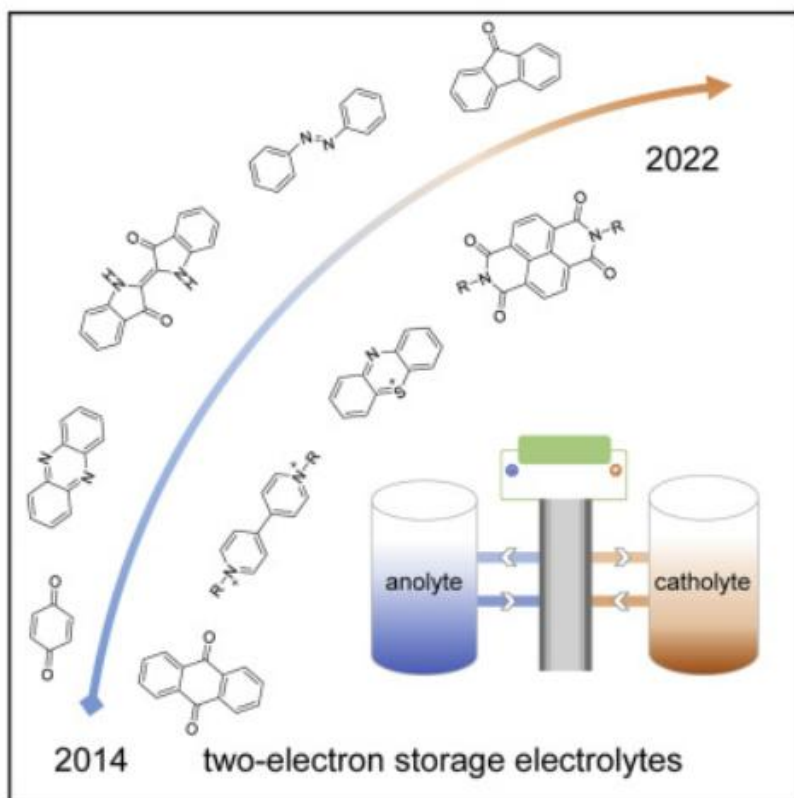
## Pilot Plant building



## 1MW-VRFB



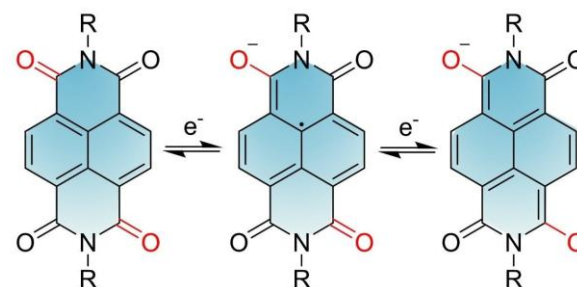
# Organic molecules species to drive RFB



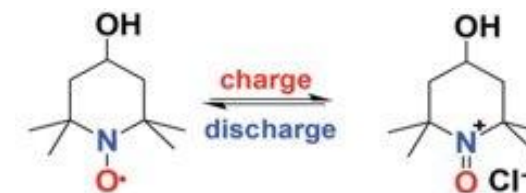
## DRAWBACKS

- ✓ Long-term stability issues
  - Degradation
  - Membrane Crossover
- ✓ Low power density/operational current density
- ✓ Poor energy density for low solubility (mM)

## K<sub>2</sub>GABA-NDI



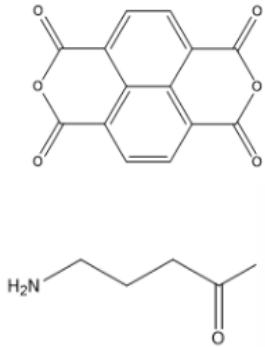
## 4-Hydroxy TEMPO



Tang et al. Cell Reports Physical Science 3, 101195, 21, 2022

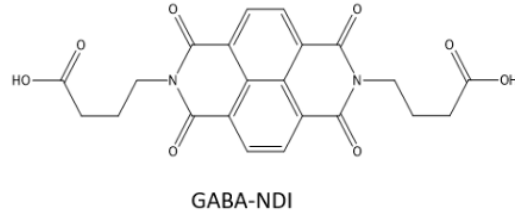
# K<sup>+</sup>-Functionalized NDI-GABA as Targeted Redox-Active Molecules

## Precursors



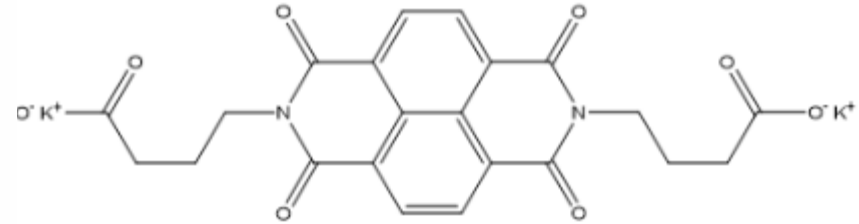
Yield 95%

## GABA-NDI



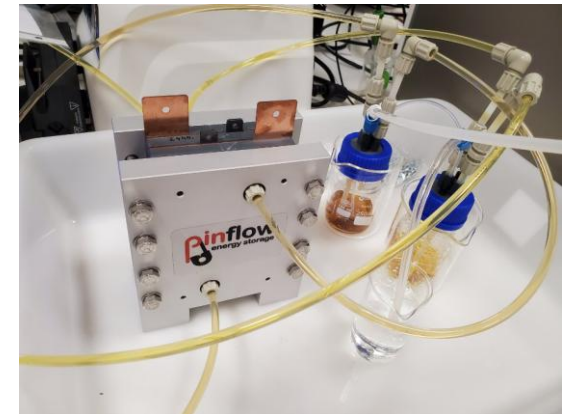
Yield 85%

## K<sub>2</sub>GABA-NDI



## BENEFITS

- ✓ Solubility in mild pH : Reduces corrosion of cell components; Is safer and more environmentally friendly and Minimizes degradation of sensitive organic species
- ✓ Up to 0.4 M in 1 M NaCl with 2-electron transfer : Theoretical capacity 1.71 Ah
- ✓ 11 g



# Beyond Molecules: The Electrode as a Key Limiting Factor for Power Density

## ROLE

- ✓ Reaction kinetics at the electrode surface
- ✓ Electronic conductivity
- ✓ Wettability
- ✓ Mass transport: facilitated by their 3D porous network, which enables efficient diffusion of redox species throughout the electrode structure

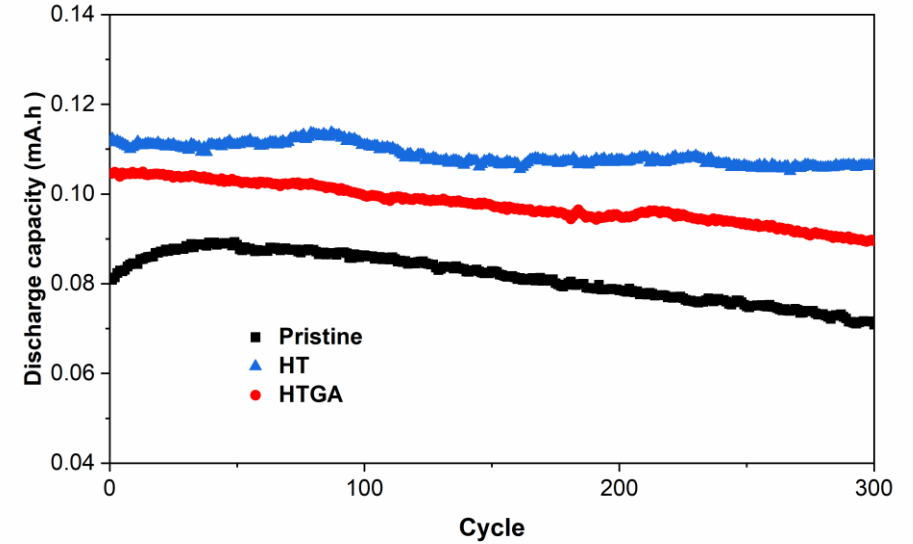
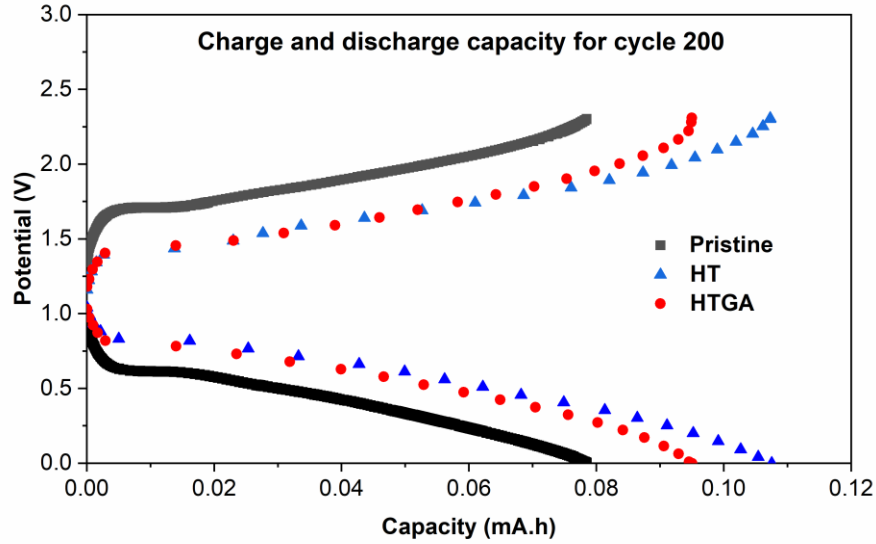
## SURFACE FUNCTIONALIZATION OF COMMERCIAL ELECTRODE SURFACE



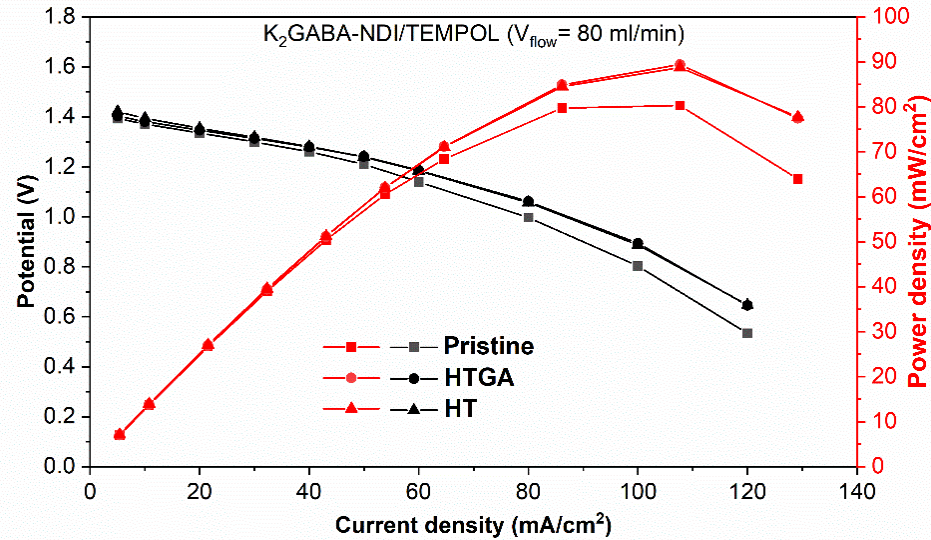
## BOOSTING ORFB POWER via ELECTRODE FUNCTIONALIZATION

- ✓ Oxygen – rich groups by thermal treatment in air: Thermal treatment 48 h at 450°C (HT)
- ✓ Combination of Oxygen and Nitrogen groups by with thermal treatment with a glucosamine hydrochloride polymer (HTGA)
- ✓ Incorporation of oxygen groups by OXYGEN ION BEAM: Beam energy: 1 MeV, Current: 0,9 μA, dose :  $1 \times 10^{15}$  atoms/cm<sup>2</sup> (Oxygen irradiation)

# Role of Oxygen and Nitrogen Atoms in Electrode Surface Engineering



**Operational Conditions:**  
 80 mL 40 mM K<sub>2</sub>GABA-NDI  
 80 mL 80 mM TEMPO  
 100mAcm<sup>-2</sup>



# Surface Wetting behaviour of functionalized electrodes

## Contact angle measurements

Pristine (angle=124°)

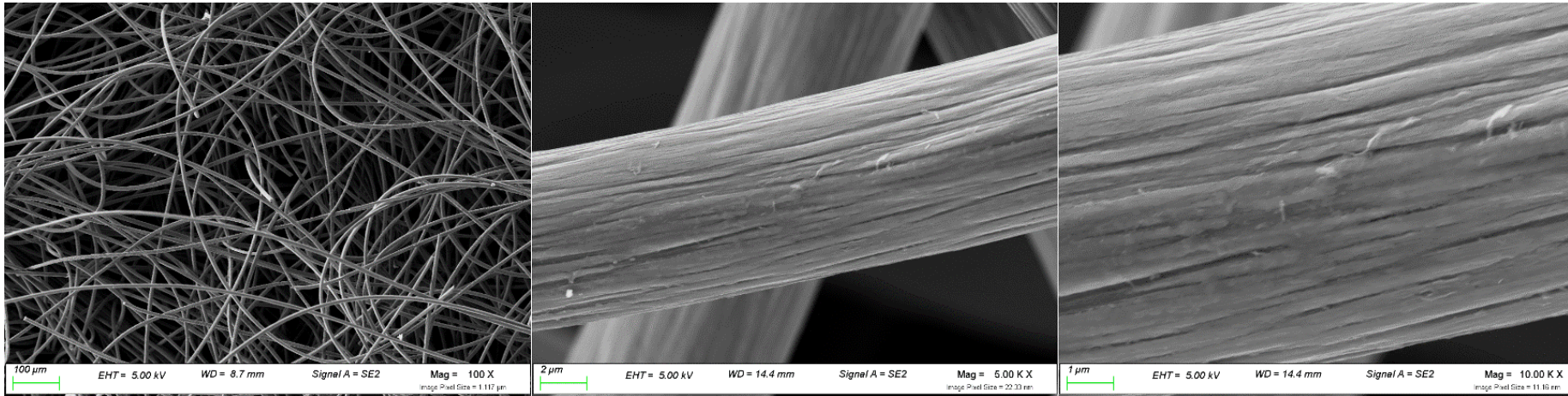


After thermal treatment (hydrophilic)



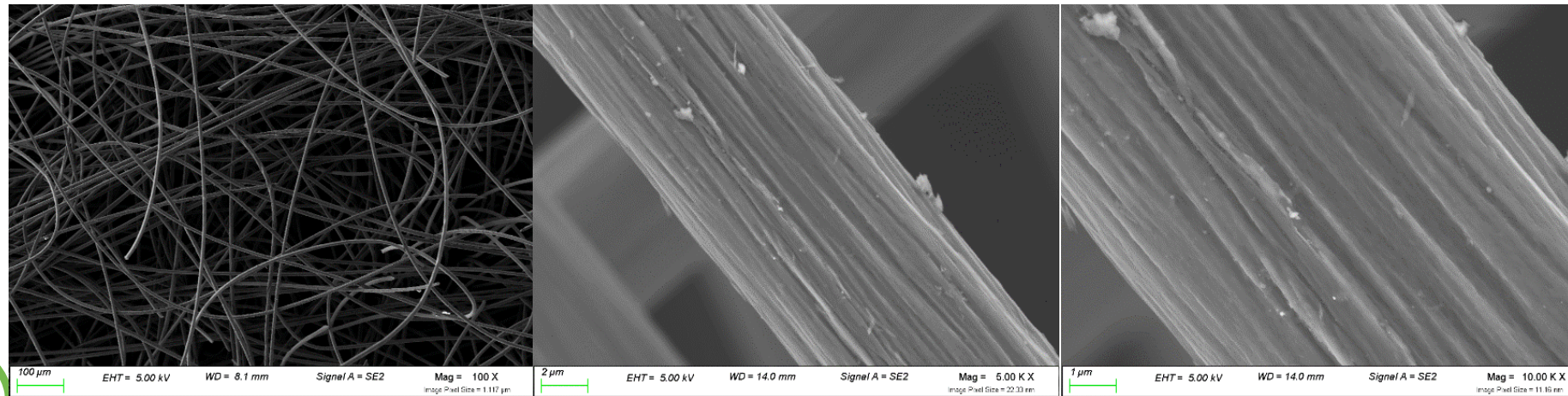
# Oxygen Ion BEAM treatment: Morphology

## Pristine felt



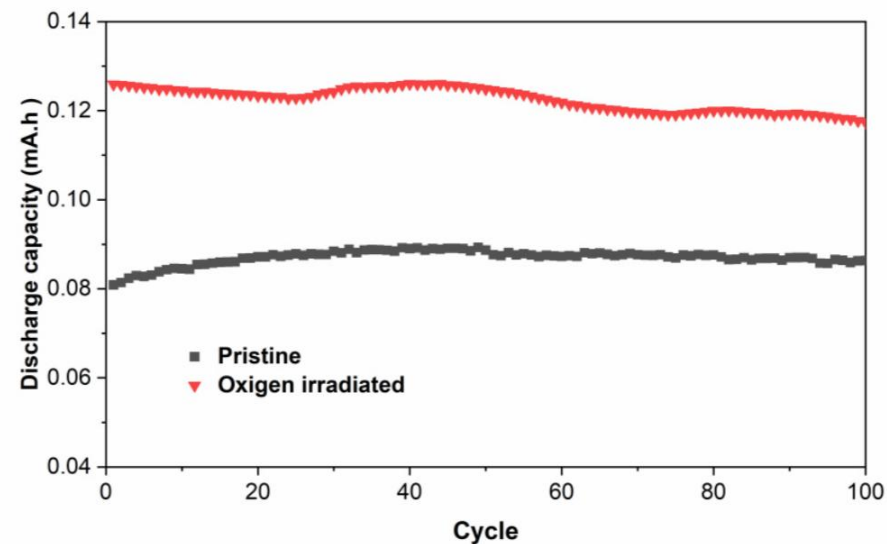
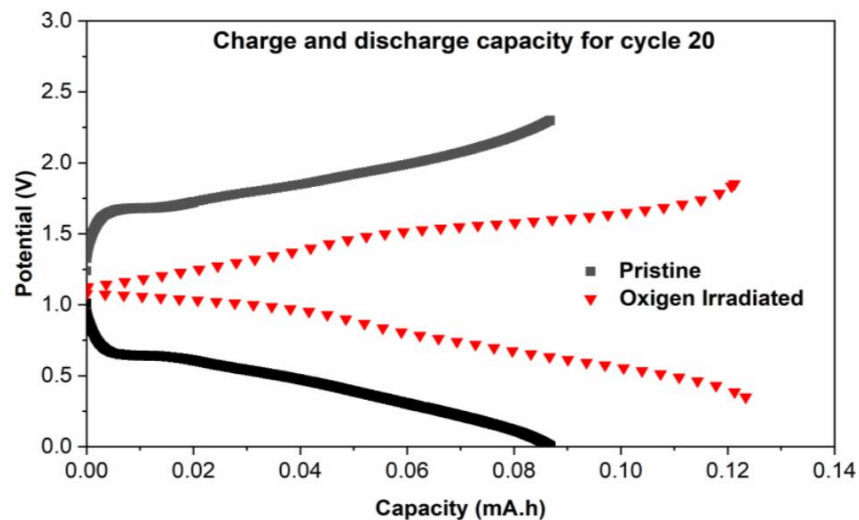
EDX  
C= 100%  
O=0%

## Oxygen Ion Beam treated:

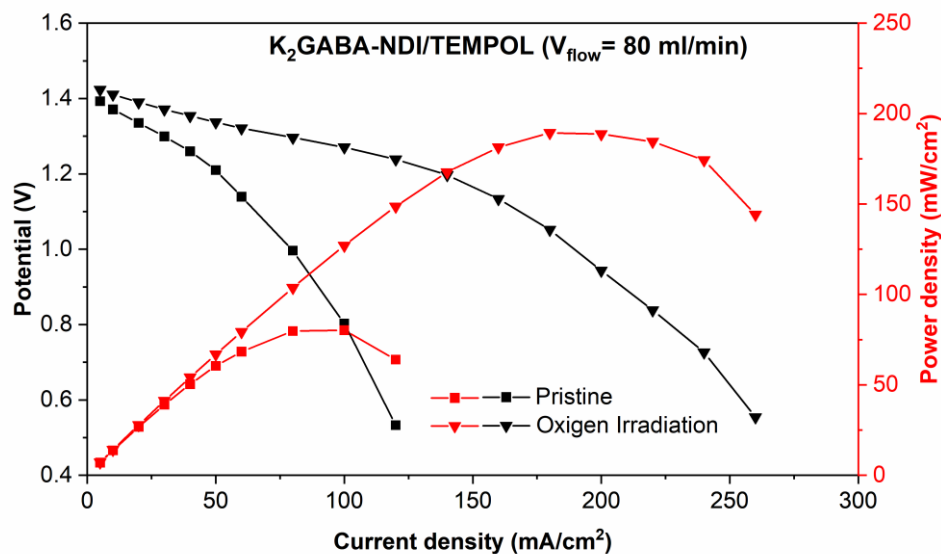


EDX  
C= 88,8 %  
O= 11.2%

# Oxygen-Based Surface Engineering to Boost ORFB Power



**Operational Conditions:**  
 80 mL 40 mM K<sub>2</sub>GABA-NDI  
 80 mL 80 mM TEMPO  
 100mAcm<sup>-2</sup>



# Take away messages

- ✓ **Surface functionalization significantly influences electrode performance**, impacting both wettability and electron transfer kinetics.
- ✓ **Incorporation of oxygen- containing groups** enhances surface polarity, improves electrolyte contact, and facilitates redox reactions.
- ✓ **Electrode wettability is a critical factor** in maximizing active surface utilization and mass transport within porous structures.
- ✓ **Power output can be enhanced** by introducing oxygen-containing functional groups via beam irradiation, which improves surface reactivity and charge transfer.
- ✓ **Beam-induced introduction of oxygen-containing groups** enhances electrode wettability and electronic coupling, leading to improved long-term stability and capacity performance in organic redox flow batteries.

# Acknowledgments



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# Thank you for your Kindly attention

