Ongoing Research in Biophysics and FR **Potential Applications** Michael Mayer Adolphe Merkle Institute, University of Fribourg **Revealing Conformational** 2 **Building an Artificial Characterizing Soluble Dynamics of Single Proteins Electric Organ Protein Aggregates** DNH structure SiN. robability Density 0.004

Oligomer size





Building an Artificial Electric Organ

Electric "Eel" generates up to 860 Volts

Torpedo Ray generates up to 1200 W



Nature 552, 214-218, 2017

Adv. Mat. 33, 2101757, 2021



Electrophorus electricus: The Electric "Eel"



Schroeder, Guha, et al., Nature **552**, 214-218, 2017

Gotter *et al.*, *Comp. Biochem. Physiol. A Mol. Integr. Physiol.*, **1998**



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Printing Arrays of Hydrogel Compartments





Schroeder, Guha, et al., Nature 552, 214-218, 2017



Activation of Hydrogel Power Sources: 110 V



Schroeder, Guha, et al., Nature 552, 214-218, 2017

2,449 gels, 612 tetrameric gel cells, V_{oc} = 110 V



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Ventral

Torpedo Rays Maximize Current Output





Torpedo: Up to 60 V and 1.2 $\ensuremath{\mathsf{kW}}$

Electric Eel: Up to 860 V and 0.1 kW





Using Paper Substrate and Optimized System, We can Power Simple Electronic Devices



Guha, Kalkus et al., Adv. Mat. 33, 2101757, 2021

Power from human breath



 $CO_2 + 2RNH_2 \leftrightarrow RNHCO_2^- + RNH_3^+$

 $CO_2 + H_2O \leftrightarrow HCO_3^- + H^+$

 $CO_2 + RNH_2 + H_2O \leftrightarrow RNH_3^+ + HCO_3^-$



27 Repeating Cells 3.0 V Open Circuit Voltage 0.06 W/m²/cell Power Density



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Kalkus et al, *Advanced Science*, 8, **2021**

Kalkus et al, *Energy and Fuel*s, 36, **2022**







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Team and Collaborators





















UNI FR



Characterizing Soluble Protein Aggregates

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OK

Analysis of Heterogeneous Particles?

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Determination of Volume and Shape









Single Particle Analysis





ACS Nano 2023, 17, 13, 12325-12335













Latest Generation of Nanopores









Team and Collaborators





Dr. Aziz Fennouri Dr. Olivia Eggenberger

Dr. Peter Nirmalraj Simon Mayer Jessica Dupasquier



Conformational Dynamics of Proteins





Maltose binding protein (MBP) in the apo (PDB ID: 1N3W) and maltose-bound (PDB ID: 1N3X) states (https://doi.org/10.7554/eLife.37248.003)

Conformational Dynamics of Citrate Synthase



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Conformational Dynamics of Hemoglobin





Team and Collaborators







Prof. Cuifeng Ying

Dr. Edona Karakaci











Thanks to all Alumni and...







BioPhysics Michael Mayer





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