
Presentation in Group Meeting at
23.06.2009
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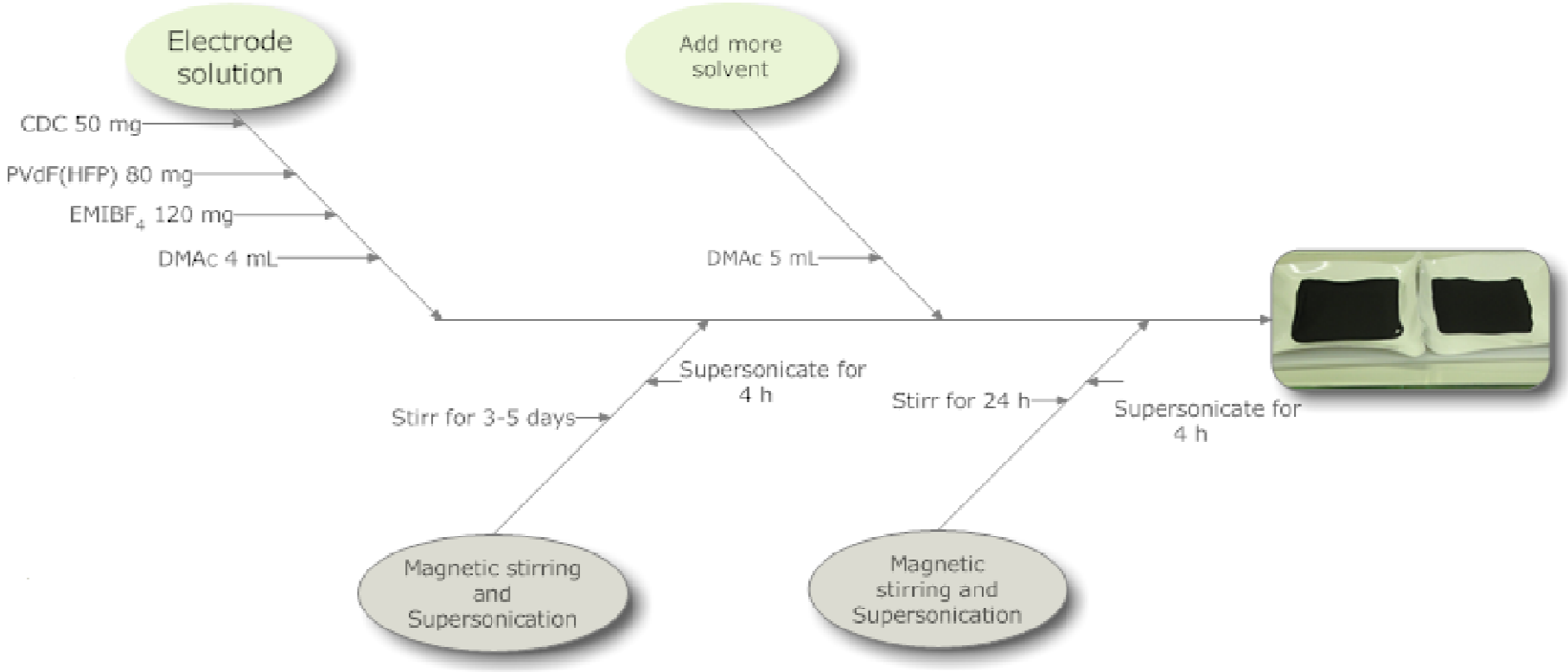
Outline

- Overview of electrode prepartion method
- Actuators prepared during visitation
- Synthesis of asymmetrical actuators, results and discussion about working mechanism
- Synthesis of actuators containing CDC and CNT with different ratio, properties of CDC used for synthesis, actuator measurement results and data analysis

Synthesis of electrode films for 3-layer actuator



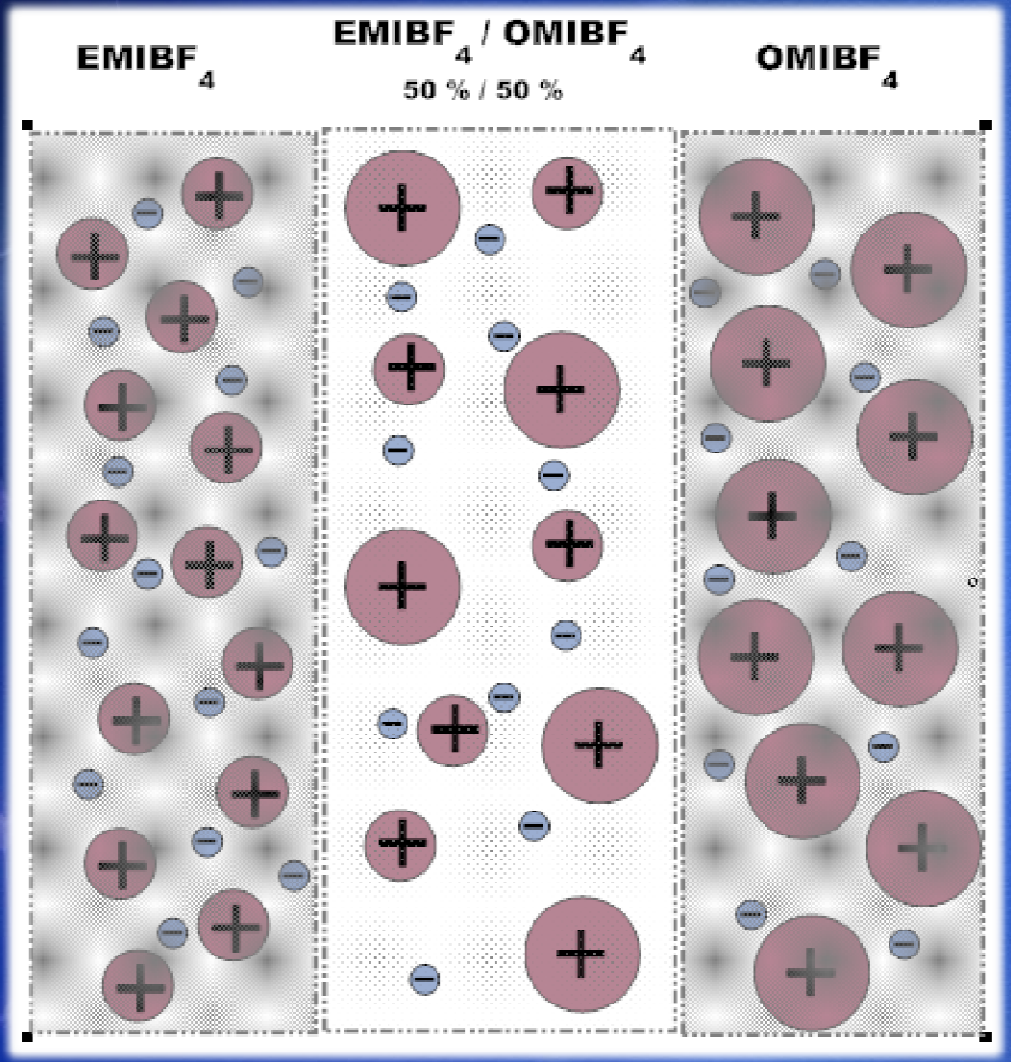
Synthesis notes:

- Beside CNTs the CDC used to prepare electrode sheets:25 mg CDC+25 mg CNT (1); 50 mg CNT+25 mg CDC (2)
- Two kind of Ionic Liquids- $EMIBF_4$ and $OMIBF_4$ used for synthesis
- Asymmetrical actuator with $EMIBF_4$ and $OMIBF_4$ electrodes and with membrane containing 50% $EMIBF_4$ and 50% $OMIBF_4$ between them is prepared

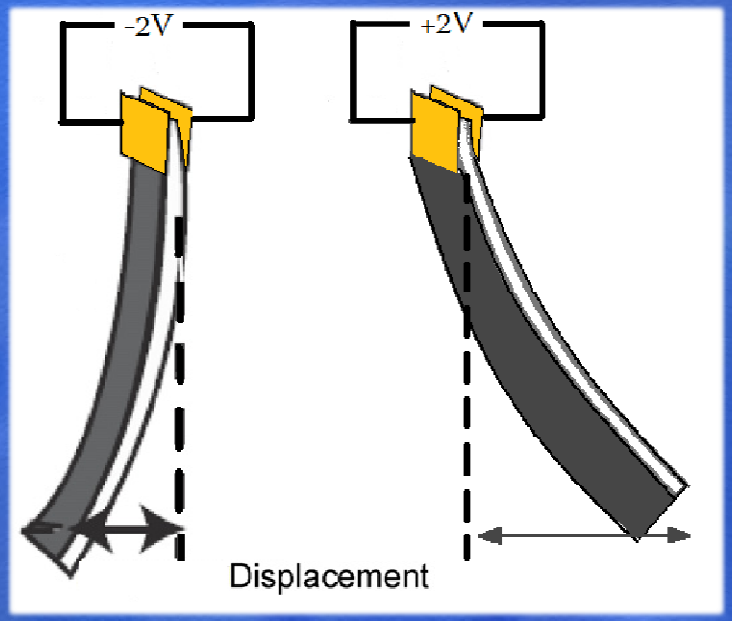
Actuators prepared during visitation

Type	Standard	Asymmetrical			CDC + CNT		
Content	I	II	III	IV	V	VI	VII
Electrode A							
Ionic liquid	$EMIBF_4$	$EMIBF_4$	$EMIBF_4$	$EMIBF_4$	$EMIBF_4$	$EMIBF_4$	$EMIBF_4$
Carbon material	CNT	CNT	CNT	CNT	50 mg CDC	25 mg CNT 25 mg CDC	50 mg CNT 25 mg CDC
Polymer	PVdF	PVdF	PVdF	PVdF	PVdF	PVdF	PVdF
Electrode B							
Ionic liquid	$EMIBF_4$	$OMIBF_4$	$OMIBF_4$	$OMIBF_4$	$EMIBF_4$	$EMIBF_4$	$EMIBF_4$
Carbon material	CNT	CNT	CNT	CNT	50 mg CDC	25 mg CNT 25 mg CDC	50 mg CNT 25 mg CDC
Polymer	PVdF	PVdF	PVdF	PVdF	PVdF	PVdF	PVdF
Membrane							
Ionic liquid	$EMIBF_4$	50/50	$EMIBF_4$	$OMIBF_4$	$EMIBF_4$	$EMIBF_4$	$EMIBF_4$
Polymer	PVdF	PVdF	PVdF	PVdF	PVdF	PVdF	PVdF

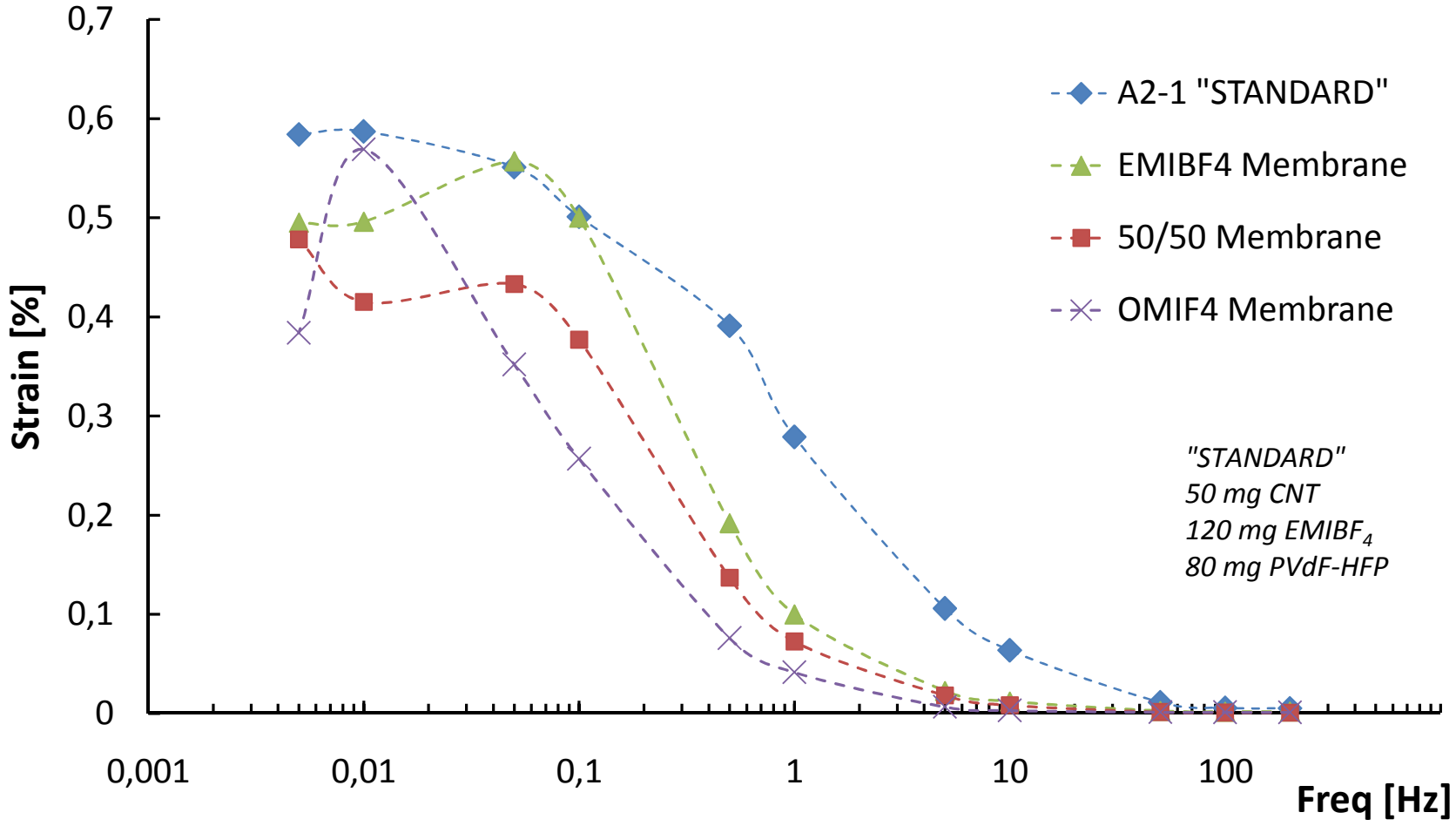
Asymmetrical actuator based on EMI^+ and OMI^+ cations



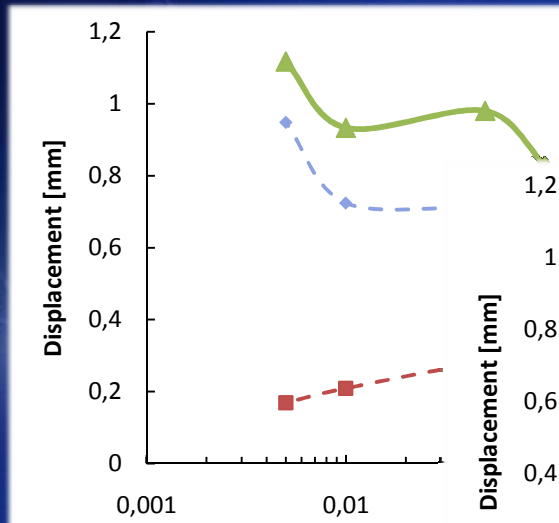
Ionic liquid	Cation
$EMIBF_4$	$R = C_2H_5$
$OMIBF_4$	$R = C_8H_{17}$



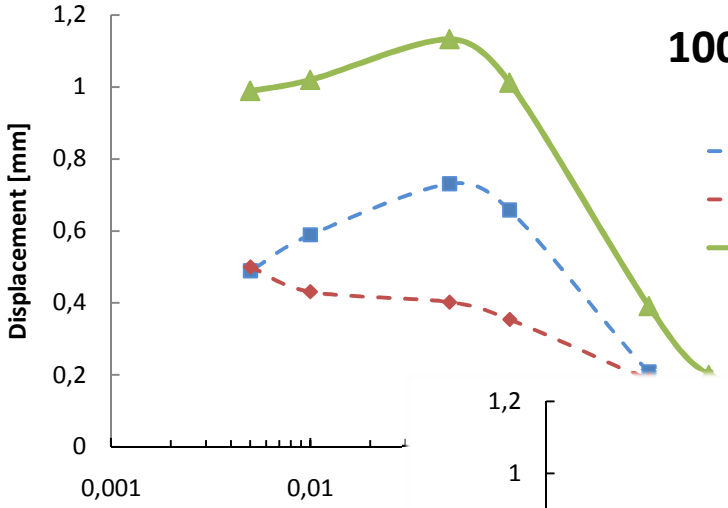
Performance of asymmetrical actuators at ± 2V



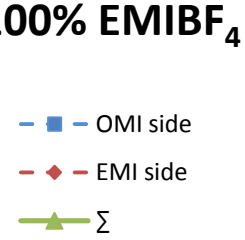
Asymmetrical displacement of actuators

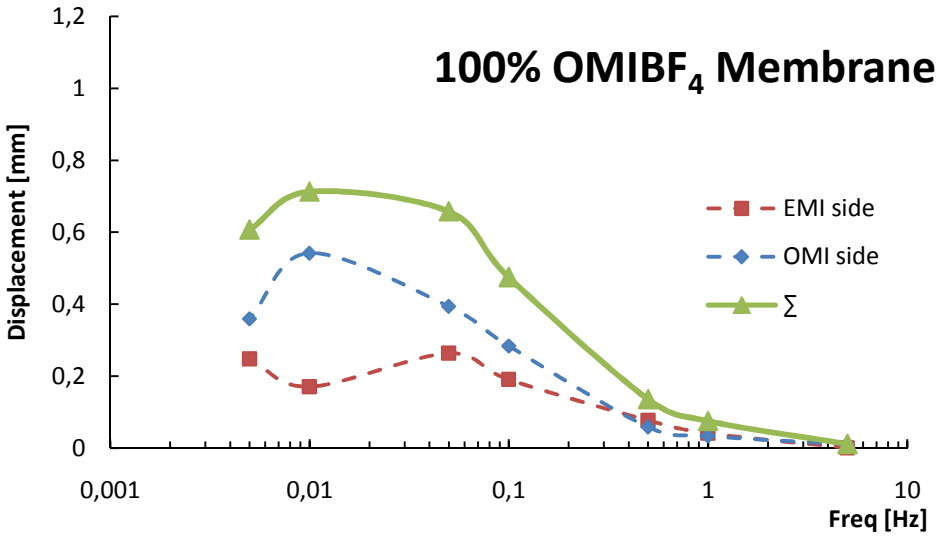


50/50 Membrane



100% $EMIBF_4$





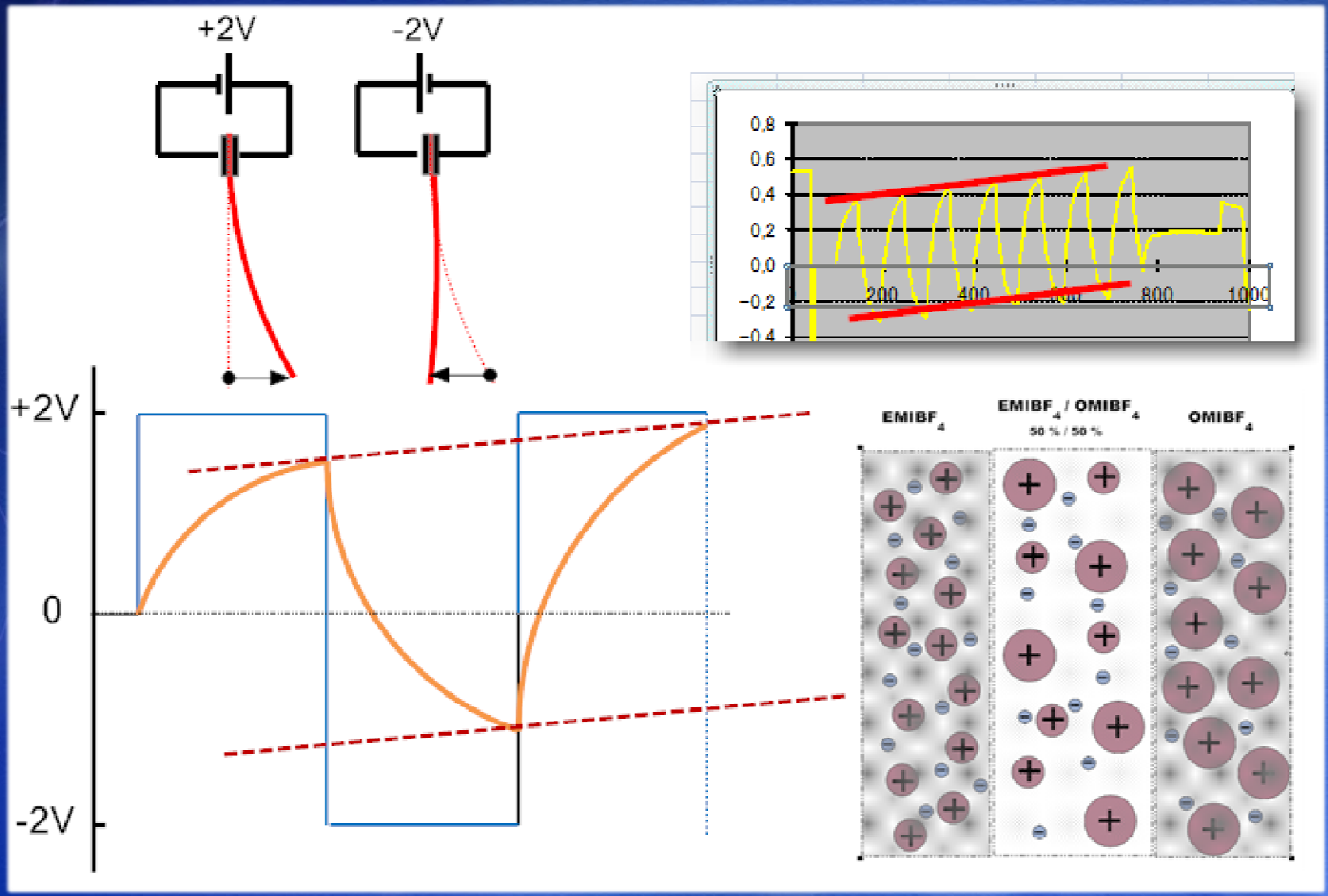
100% $OMIBF_4$ Membrane

Young's modulus (E):

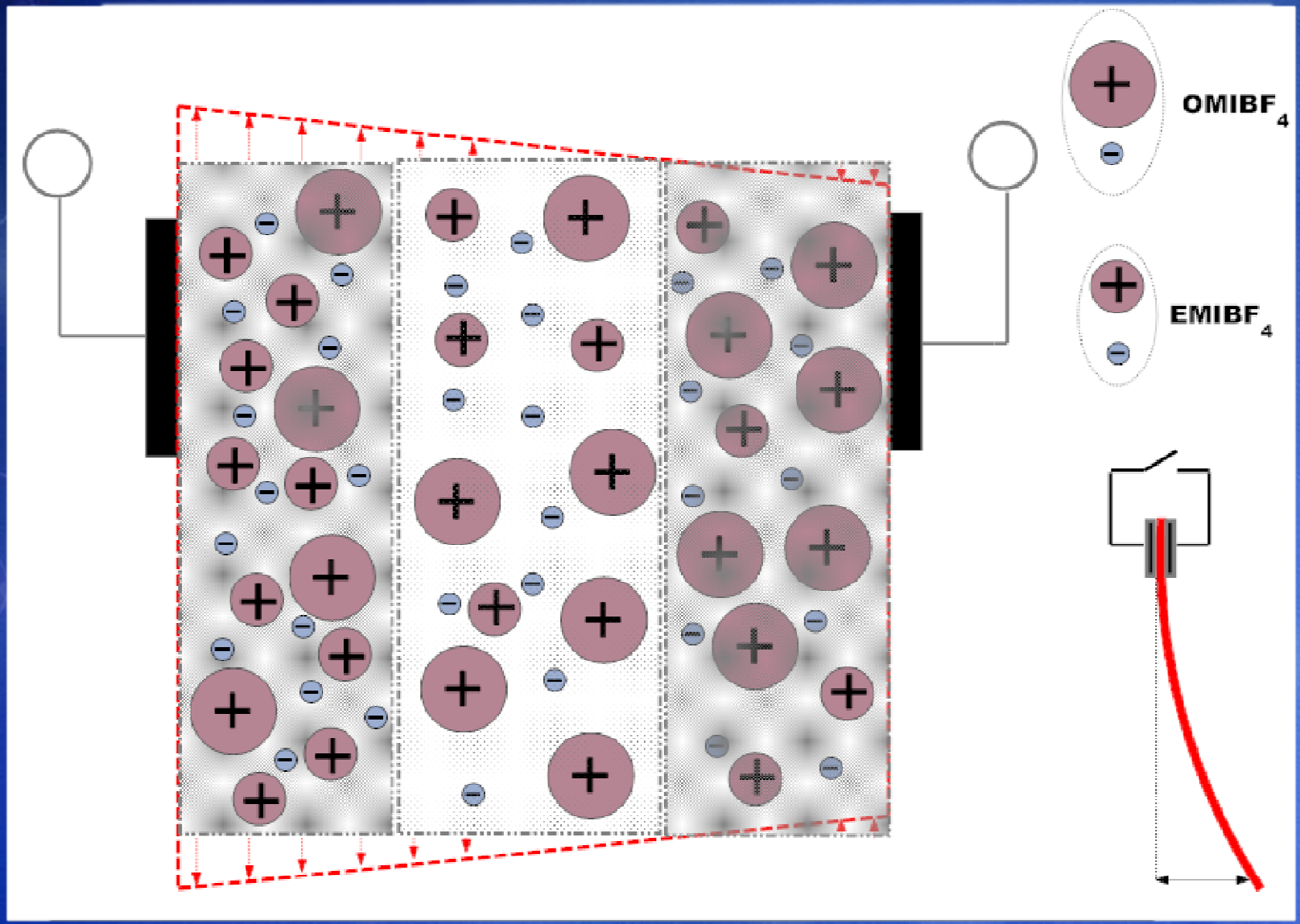
E for $OMIBF_4$ electrode = 64 Mpa

E for $EMIBF_4$ electrode = 268 MPa

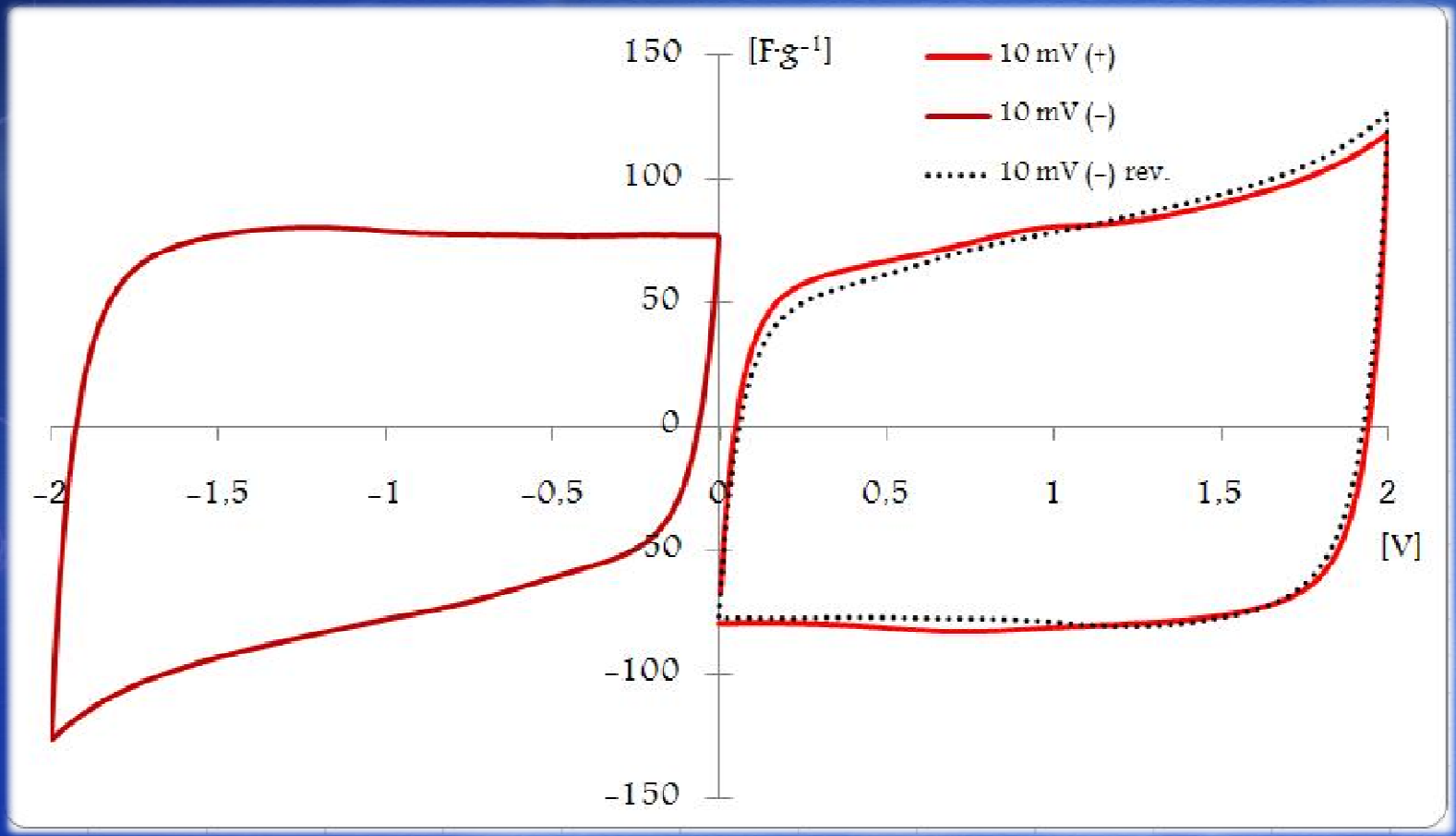
Behavior of asymmetrical actuator during mesurement



Behavior of asymmetrical actuator during mesurement



Gravimetric capacitance of asymmetrical actuator with 50/50 membrane, calculated from CV measurements



CNT and CDC based 3-layer actuator electrode layers:

A1

CNT (ID:PO356) 50.1 mg; CDC (TiC-800) 25.1 mg; $EMIBF_4$ 124.5 mg
PVdF-HFP 80.1 mg; DMAc ~(4 mL + 5 mL)

A2

CNT (ID:PO356) 25,1 mg; CDC (TiC-800) 25,2 mg; $EMIBF_4$ 124 mg
PVdF-HFP 80 mg; DMAc ~(4 mL + 5 mL)

A3

CDC (TiC-800) 50.2 mg; $EMIBF_4$ 124.5 mg; PVdF-HFP 80.1 mg;
DMAc ~(4 mL + 5 mL)

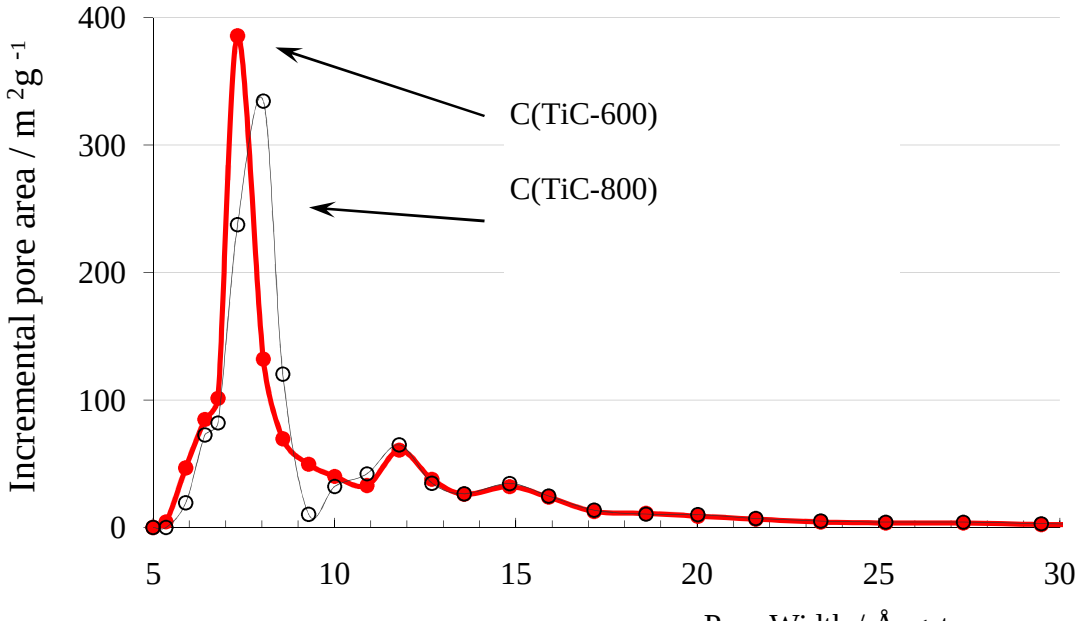
Membrane

$EMIBF_4$ 202 mg; PVdF-HFP 204.3 mg; MP 2mL and PC 497 mg

Properties of CDC used for 3-layer actuator synthesis

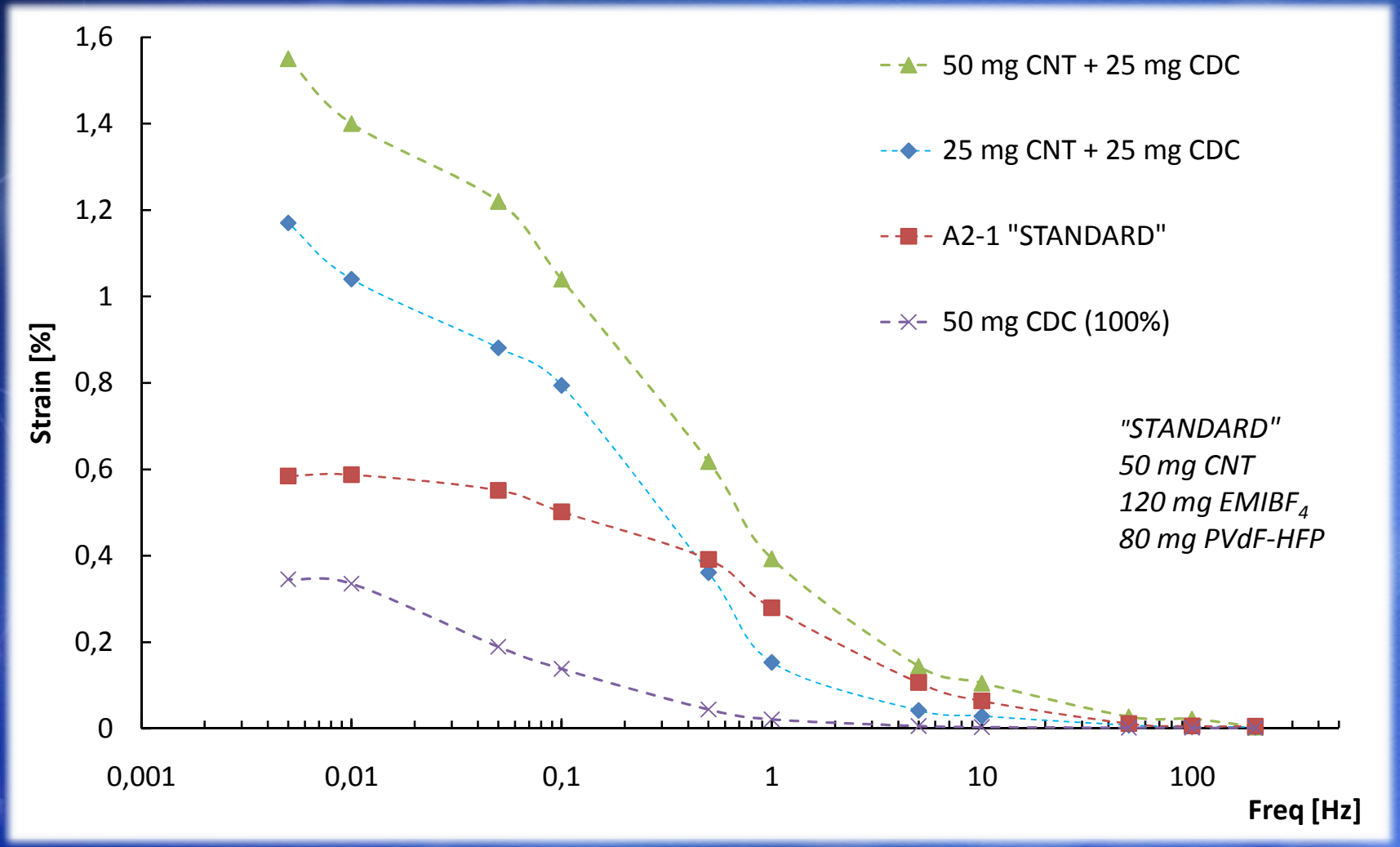
Material / Parameter	$T_{chlorination}$ [°C]	S_A [$m^2 \cdot g^{-1}$]	V_p [$m^3 \cdot g^{-1}$]	V_m [$m^3 \cdot g^{-1}$]	APS
TiC-800	800	1470	0.712	0.594	10.2

$T_{Chlorin}$- Temperature of chlorination (powder synthesis)
S_A- Specific area
V_p- Volume of porosity per gram
V_μ- Volume of micropores per gram
APS- Average pore size
(Measured from N_2 adsorption)

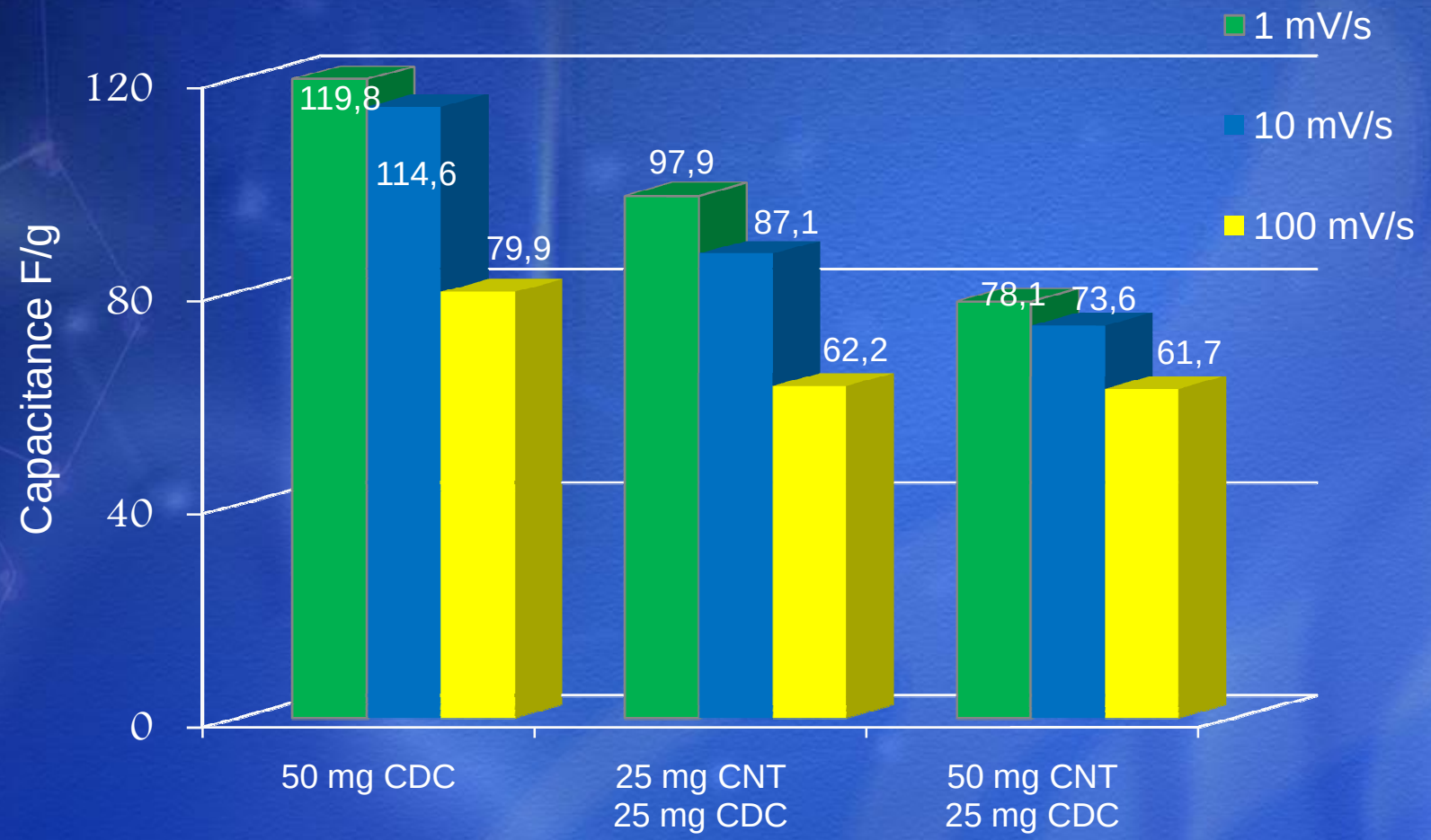


Carbon Nanotech homepage: www.carbon.ee

Actuation performance of CNT and CDC based 3-layer actuators at ±2 V



Capacitance of CNT and CDC based actuators obtained CV measurements (± 1 V)



Thank you!

どうもありがとう。