SUPPORTING INFORMATION

Microfluidic actuator based on stimuli-responsive hydrogel grafted into Cucurbita moschata xylems

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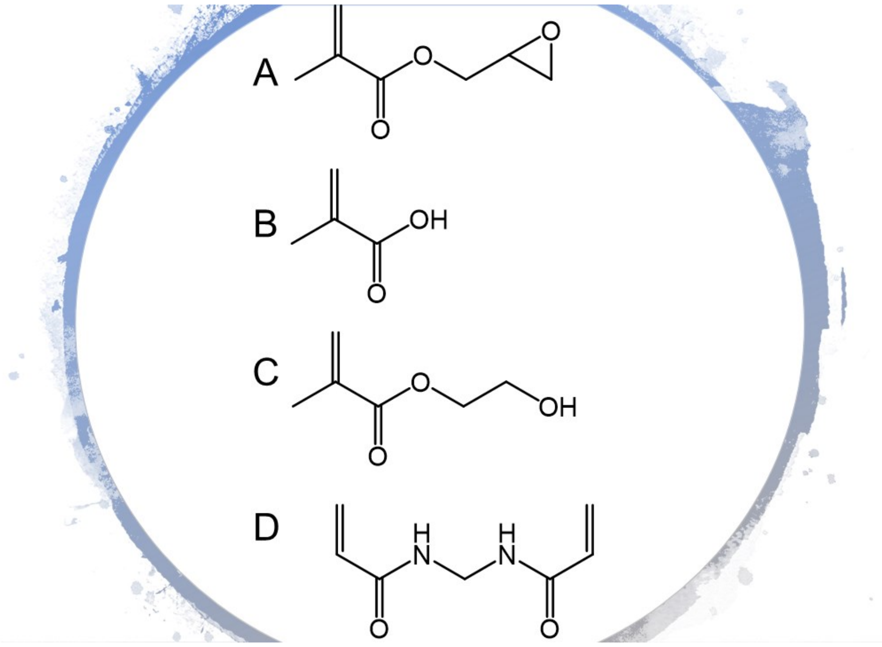


Figure S.1. Molecular structure of a) GMA, b) AA, c) HEMA and d) BIS vinyl compound.

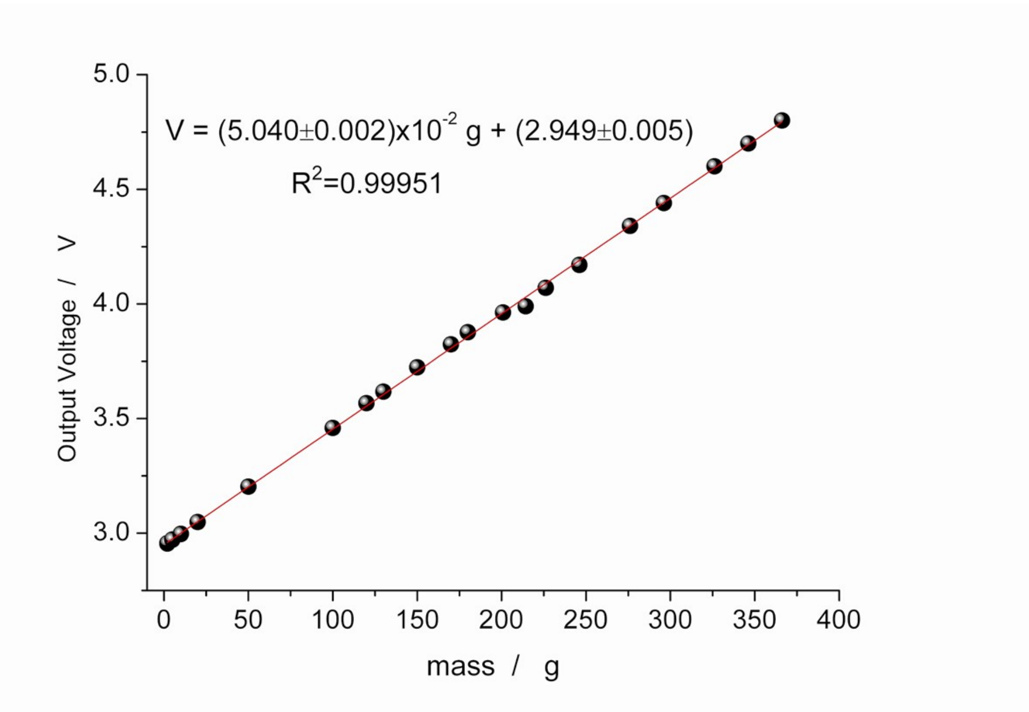


Figure S.2A. Calibration curve of Volts (V) versus mass (g) of electronic amplifier in response to a load cell tested with different calibration mass sets. Inset: adjust function and determination coefficient.

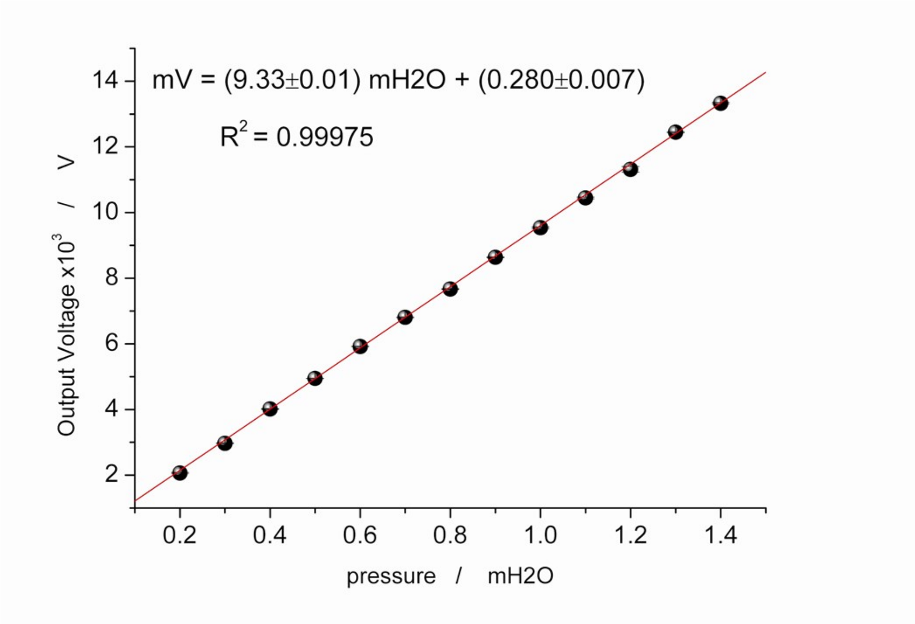


Figure S.2B. Calibration curve of Output Voltage (mV) versus pressure (mH2O) of electronic amplifier in response to pressure sensor tested at different known pressures. Inset: adjust function and determination coefficient.

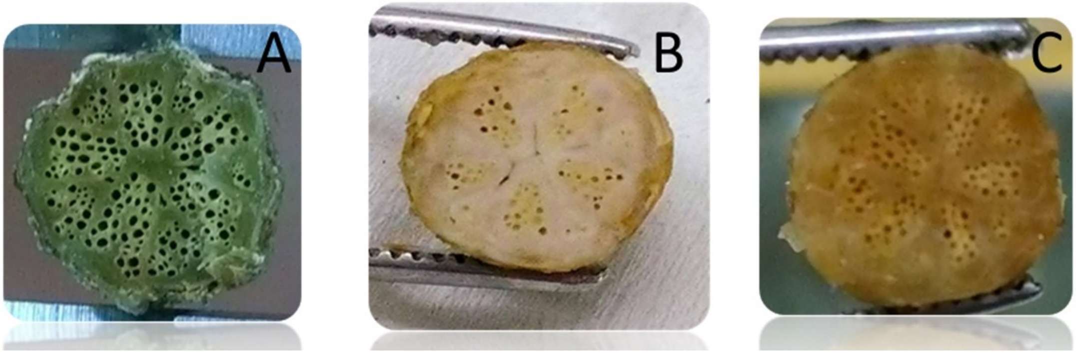


Figure S3. Photographs of cross sections of a pristine vegetal stem (A), after GMA reaction (B) and modification by polymer grafting (C) .

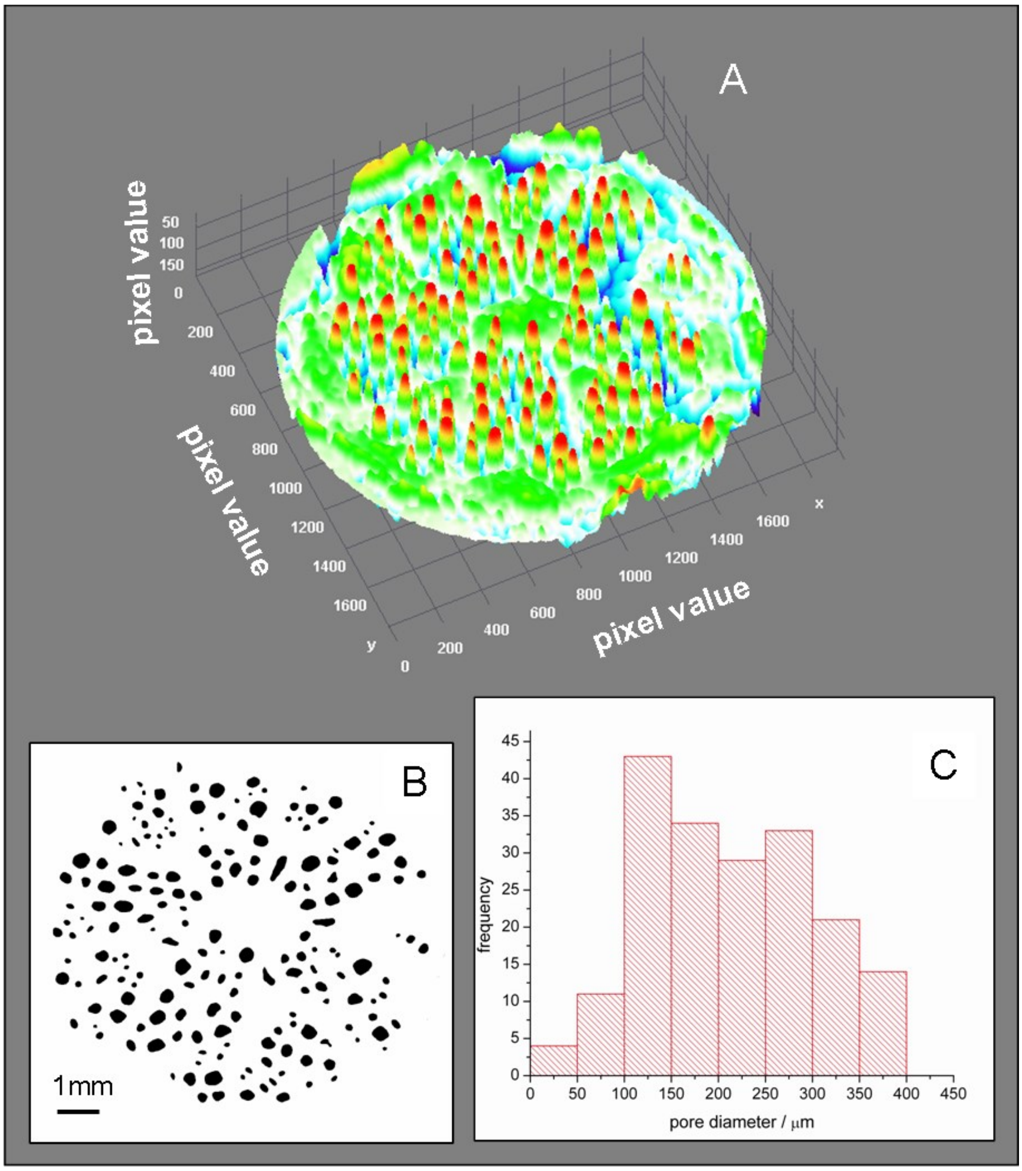
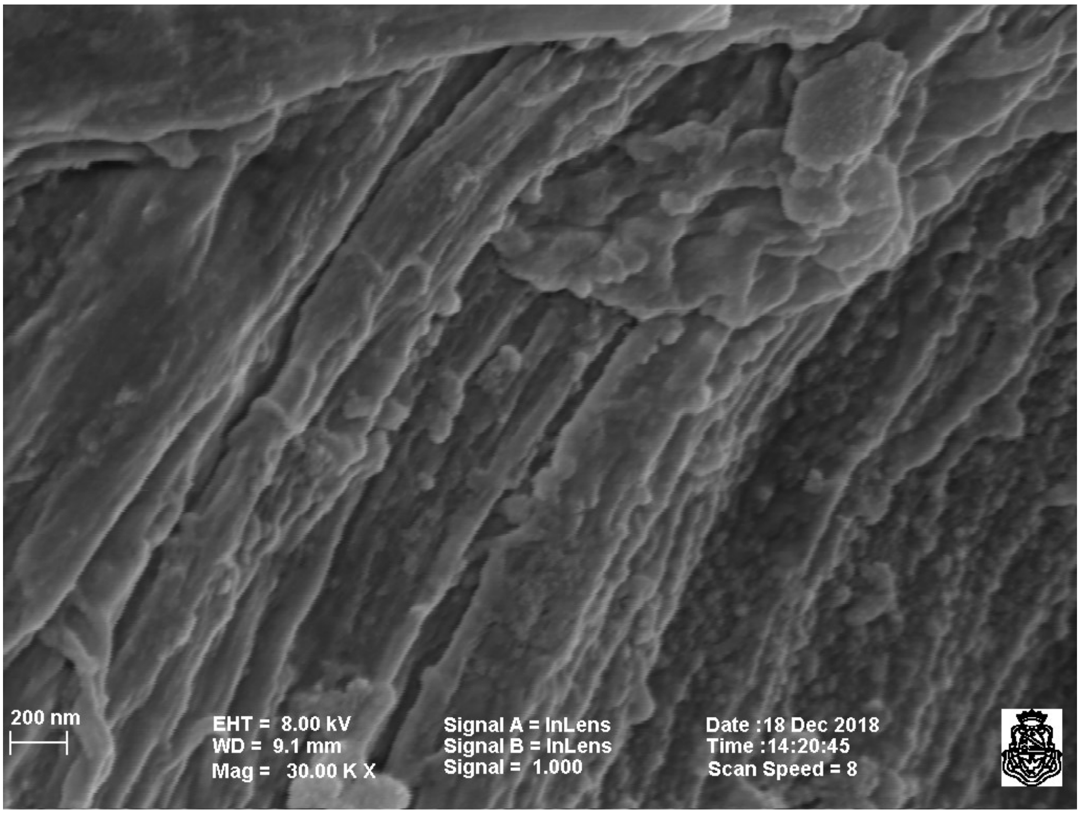


Figure S.4. Pore size and spatial distribution based on image processing. A) Volume viewer of transversal section of a valve without modifications. B) Black dots indicate the distribution and size of capillaries on the cross section of pristine stem. C) Histogram of xylem diameters determined from B.


200 nm
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WD = 9.1 mm
Mag = 30.00 K X
Signal A = InLens
Signal B = InLens
Signal = 1.000
Date :18 Dec 2018
Time :14:20:45
Scan Speed = 8

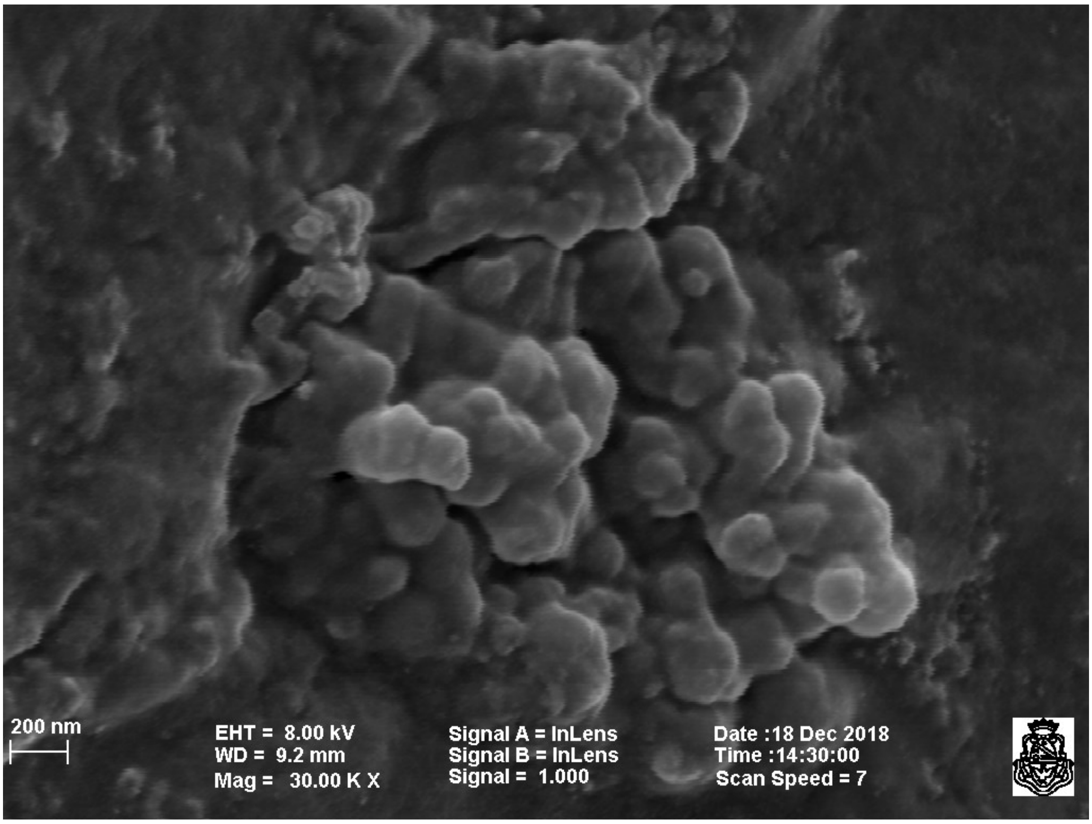

Figure S.5. SEM micrograph of internal xylem wall before (top) and after (botton) modification with the hydrogel observed at 30kX. Pristine wall shows fibrous aspect and in contrast the grafted hydrogel exhibits a typical globular morphology.

Equations and uncertainties

EQUATIONS

Equation 1:

$$q_v = \frac{\pi\, r^4\, \Delta P}{8\, \eta\, L}$$

Equation 2:

$$q_v = q_m\, \delta^{-1}$$

Equation 3:

$$Q_m = \sum_{i=1}^{n} q_m(i) \cong \bar{n}\,\bar{q}_m$$

Equation 4:

$$\bar{d}_c = 2\sqrt[4]{\frac{\bar{q}_m\, 8\,\eta\, L}{\delta\,\pi\,\Delta P}}$$

FURTHER EQUATIONS

Average mass flux in each capillary:

$$\bar{q}_m = \frac{Q_m}{\bar{n}}$$

Uncertainty estimation for $\bar{q}_m\,\bar{q}_m$ (average mass flux in each capillary):

$$u(\bar{q}_m) = \bar{q}_m \sqrt{\left(\frac{u(Q_m)}{Q_m}\right)^2 + \left(\frac{u(\bar{n})}{\bar{n}}\right)^2}$$

Uncertainty estimation for $\bar{d}_c\,\bar{d}_c$ (average diameter of each capillary):

$$u(\bar{d}_c) = \frac{\bar{d}_c}{4}\sqrt{\left(\frac{u(\bar{q}_m)}{\bar{q}_m}\right)^2 + \left(\frac{u(\eta)}{\eta}\right)^2 + \left(\frac{u(L)}{L}\right)^2 + \left(\frac{u(\delta)}{\delta}\right)^2 + \left(\frac{u(\Delta P)}{\Delta P}\right)^2}$$

UNCERTAINTY ESTIMATION FOR COMPARISON WITH POISEUILLE MODEL

Estimation of the average mass flow in each capillary q_m

$$\bar{q}_m = \frac{Q_m}{\bar{n}}$$

$$u(\bar{q}_m) = \bar{q}_m \sqrt{\left(\frac{u(Q_m)}{Q_m}\right)^2 + \left(\frac{u(\bar{n})}{\bar{n}}\right)^2}$$

Measured mass flow	**Q_m**	6,467	+/-	0,084	g/s
Average number of capillaries	**ñ**	174	+/-	26	

		relative error	square relative error
Measured mass flow	**Q_m**	0,012989021	0,00017
Average number of capillaries	**ñ**	0,149425287	0,02233

Average mass flux in each capillary	**q_m**	**0,03717**	**+/-**	**0,005574583**	**g/s**

Estimation of the average diameter of each capillary d_c

Average mass flux in each capillary	**q_m**	0,03717	+/-	0,005574583	g/s	3,71667E-05	0	5,57458E-06	kg/s
Dynamic water viscosity	**eta**	1,0016	+/-	*	mPa.s	0,0010016	+/-	#VALUE!	Pa.s
Length of the capillarity	**L**	2,00	+/-	0,05	cm	0,02000	+/-	0,0005	m
Water density	**delta**	0,99823	+/-	*	g/cm3	998,23	+/-	#VALUE!	kg/m3
Pressure difference	**delta_P**	1,00	+/-	0,02	mH2O	9806,38	+/-	196,13	Pa

* At 20 °C; uncertainty could be estimated using variations among the temperature variations during the experiments.

		relative error	square relative error
Average mass flux in each capillary	**q_m**	0,150	2,25E-02
Dynamic water viscosity	**eta**	#VALUE!	0,00E+00
Length of the capillarity	**L**	0,025	6,25E-04
Water density	**delta**	#VALUE!	0,00E+00
Pressure difference	**delta_P**	0,020	4,00E-04
sum of square relative errors			2,35E-02

$$\bar{d}_c = 2 \sqrt[4]{\frac{\bar{q}_m \, 8 \, \eta \, L}{\delta \, \pi \, \Delta P}}$$

$$u(\bar{d}_c) = \frac{\bar{d}_c}{4} \sqrt{\left(\frac{u(\bar{q}_m)}{\bar{q}_m}\right)^2 + \left(\frac{u(\eta)}{\eta}\right)^2 + \left(\frac{u(L)}{L}\right)^2 + \left(\frac{u(\delta)}{\delta}\right)^2 + \left(\frac{u(\Delta P)}{\Delta P}\right)^2}$$

Average diameter of each capillary	**d_c**	**0,0002359**	**+/-**	**0,00000905**	**m**
Average diameter of each capillary	**d_c**	**236**	**+/-**	**9**	**micro_m**