Electronic Supporting Information (ESI)†

Triboelectric effect as a new strategy for sealing and controlling the flow in paper-based devices

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S1. Influence of charged PET sheets on dripping water

Considering the natural polarity of water molecules (its structure has both positive and negative partial charges), the electrostatic charges accumulated on the PET surface when it is rubbed (tribocharging) may be explored to change the shape (pendant drop) and position of water molecules. In order to confirm this hypothesis, an experiment was performed with a food-dye (red color) solution inside a glass burette and a tribocharged PET sheet used to attract the liquid (Fig S1).

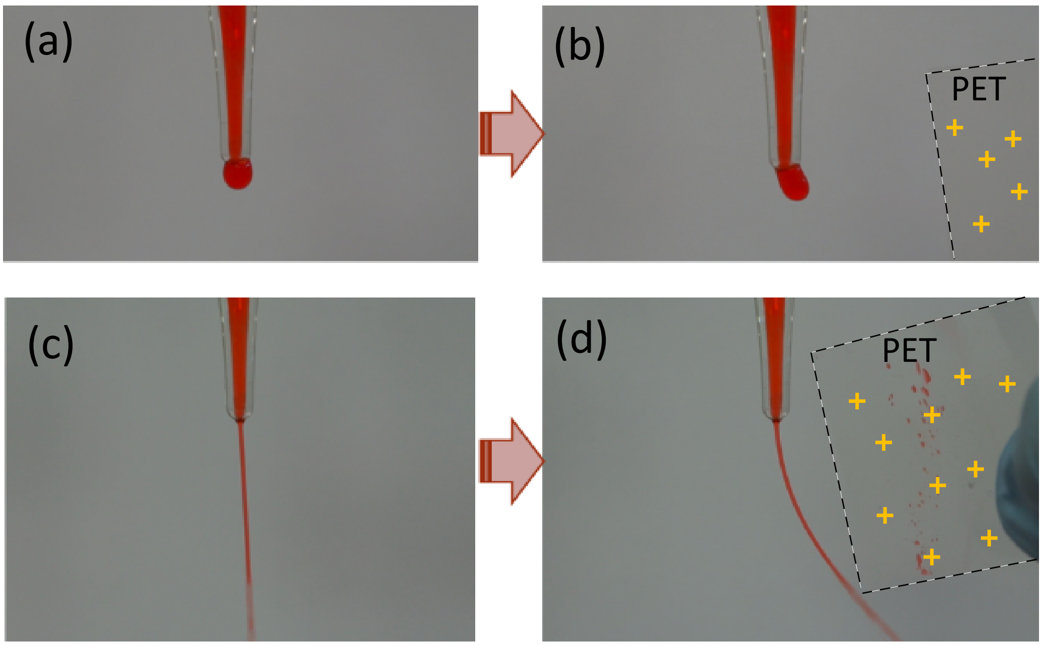

Figure S1. (a) Pendant drop of a food-dye solution inside a glass burette and (b) its deforming by approximation of tribocharged PET sheets. Straight flow (c) and its shift (d) before and after the approximation of a charged PET sheet, respectively.

Two configurations were used to perform the experiments: pendant drop (Figures S1a and S1b) and continuous flow (Figures S1c and S1d). As it can be observed in Fig. S1, the PET sheet tribocharged by rubbing on Teflon can deform the drop (Fig S1b) and the direction of dripped water (Fig. S1d) only by putting the PET sheet close to the liquid, with at least 20 mm of distance (the same attractive effect was observed when PET was rubbed on PMMA). This attractive behavior of the tribocharged PET in relation to aqueous solution can be easily used to delay the flow in paper-based devices, which is very important for several applications.

S2. Uncharged sealed µPAD

To evaluate if the electrostatic charged PET sheet has any influence on the flow rate in tribosealed devices, the same experiment performed in Fig. 1d was carried out here but with the µPAD sealed with uncharged PET sheets. To attach the PET sheets two thin glass plates (microscope slides) were attached by using clamps on the sides of the glass slides to avoid pressing the hydrophilic channel (Fig. S2a). The result obtained regarding the distance traveled by the fluid inside the channel over the time is presented in Figure S2b.

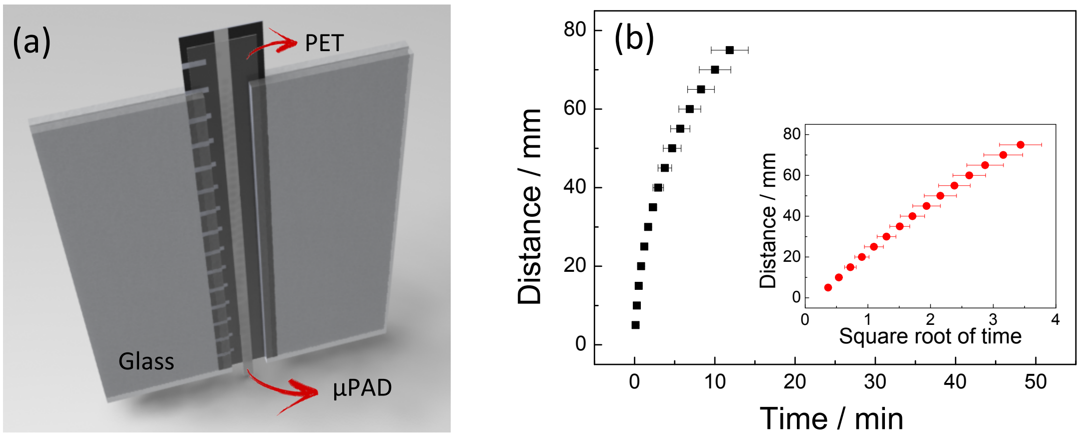

Figure S2. Distance traveled by the fluid inside the paper channel over the time for the µPADs sealed without charges. *Inside*: the distance traveled by the fluid over the square root of time.

As it can be observed in Fig. S2b, the liquid flowed 75 mm straight inside the paper channel at the same time as in the Fig. 1d for the tribosealed device (approximately 10 min). Moreover, this device showed a capillary behavior with the distance travelled by the fluid linearly related to the square root of time, as in Fig. 1d. These results suggest that the tribocharged surfaces have no influence on flow rate in paper-based devices when PET sheets are in direct contact with the aqueous solution. However, it is important to mention here that the entire device remains sealed after the flow assays suggesting that only the region in contact with the hydrophilic region is being discharged.

S3. Triboelectric delays (TEDs) with different lengths

In order to help users to use TEDs more flexibly we have performed experiments using delays with straight channels produced with different lengths. Fig. S3 shows the distance *versus* the square root of time curves for TEDs of 20, 40 and 60 mm.

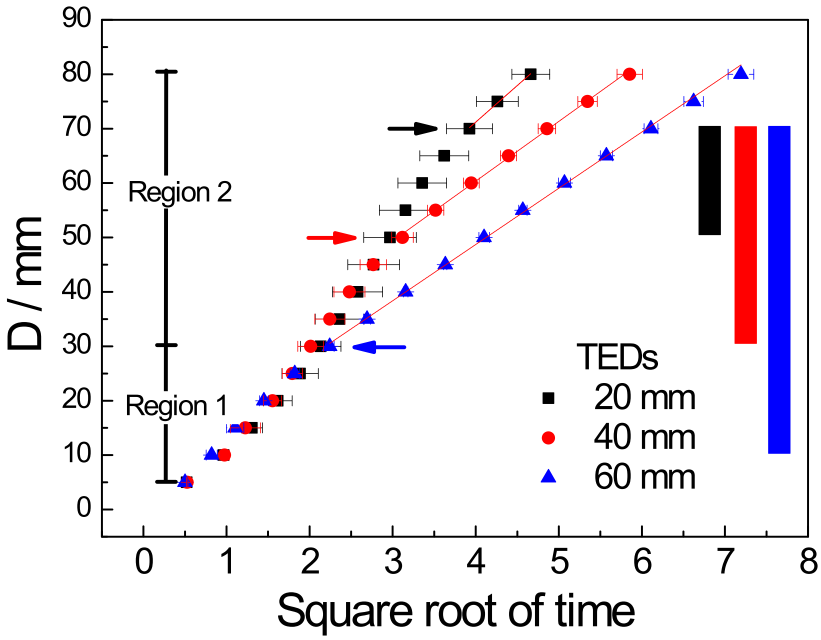

Figure S3. Distance traveled by the fluid over the square root of time using TEDs of different lengths. The paper-based strips were positioned vertically.

As it can be observed in Fig. S3, the Region 1 shows that D *vs*. $t^{1/2}$ curves are essentially the same during the first 30 mm of the channel and follows Washburn equation. These results suggests that even TEDs with a higher exposed area to the channel (TED of 60 mm) have no influence in the flow during the first 30 mm of analysis. As a consequence, paper-based channels must be longer than 30 mm. After 30 mm the flow rate can be controlled in the region 2 of the graph by changing the area of the PET sheets exposed to the channel by simply increasing the length of TEDs. For each TED, the conditions and equations are described in the Table below:

Table S3. Influence of length of TEDs, conditions for the linear part of the graph and linear equations.

Length of TEDs / mm	$D \geq z^*$ / mm	Y = a + bx
20	70	$D = 17.4 + 13.4 \cdot t^{1/2}$
40	50	$D = 16.4 + 11.0 \cdot t^{1/2}$
60	30	$D = 7.4 + 10.3 \cdot t^{1/2}$

* z is the position in the "Y" axis where the linear equation starts to be valid.

We have observed that our Washburn curves have a similar behavior when compared with other delay methods,[1, 2] however TEDs do not require changes in the geometry of the paper-based channel.

References

1. E. Fu, B. Lutz, P. Kauffman and P. Yager, *Lab on a Chip*, 2010, 10, 918.
2. B. J. Toley, B. McKenzie, T. Liang, J. R. Buser, P. Yager and E. Fu, *Analytical Chemistry*, 2013, 85, 11545.