Supplementary Information for

One-Step Polymer Screen-Printing for Microfluidic Paper-Based Analytical Device (μPAD) Fabrication

Yupaporn Sameenoi[a*], Piyaporn Na Nongkai[a], Souksanh Nouanthavong[a], Charles S. Henry[b], Duangjai Nacapricha[c]

[a]Department of Chemistry, Faculty of Science, Burapha University, Chon Buri, 20131, Thailand

[b]Department of Chemistry, Colorado State University, Fort Collins, 80523-1872, USA

[c]Department of Chemistry, Faculty of Science, Mahidol University, Bangkok, 10400, Thailand

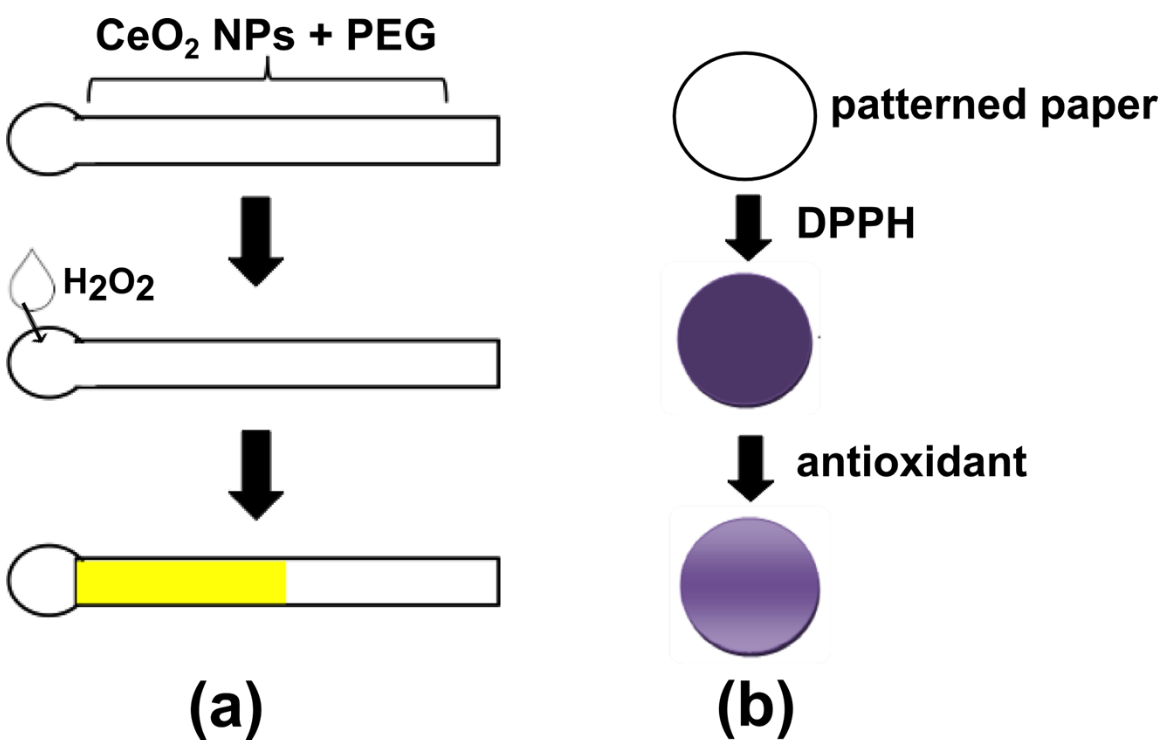


Figure S-1. Schematic diagram for analytical procedure using the fabricated paper devices for the analysis of (a) H_2O_2 in a distance-based format and (b) antioxidant activity using DPPH assay in a well-based format.

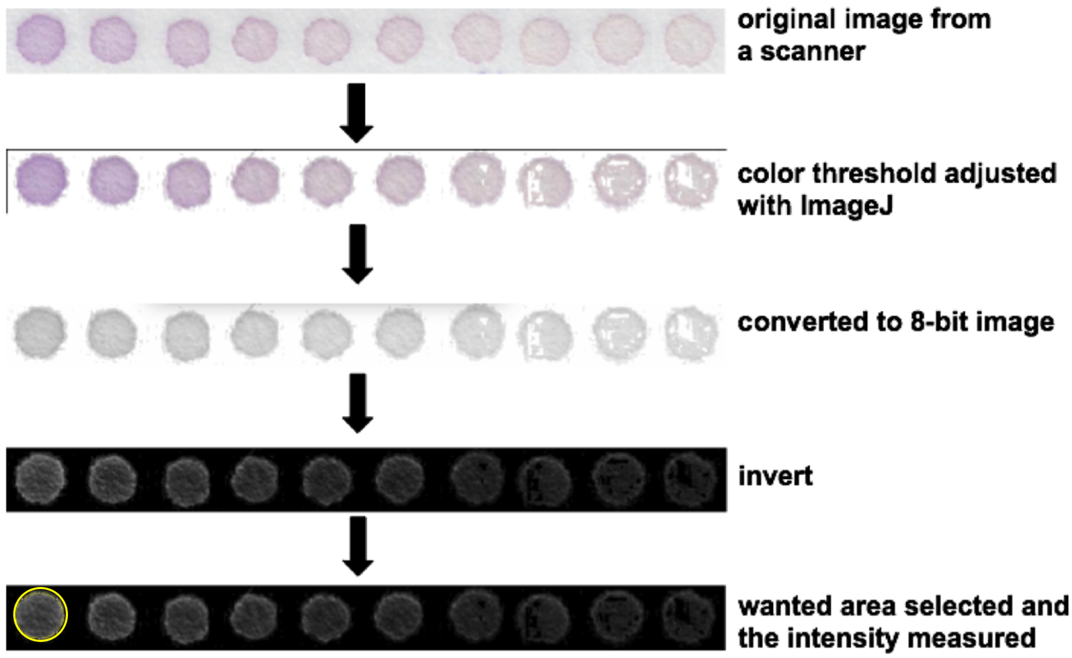
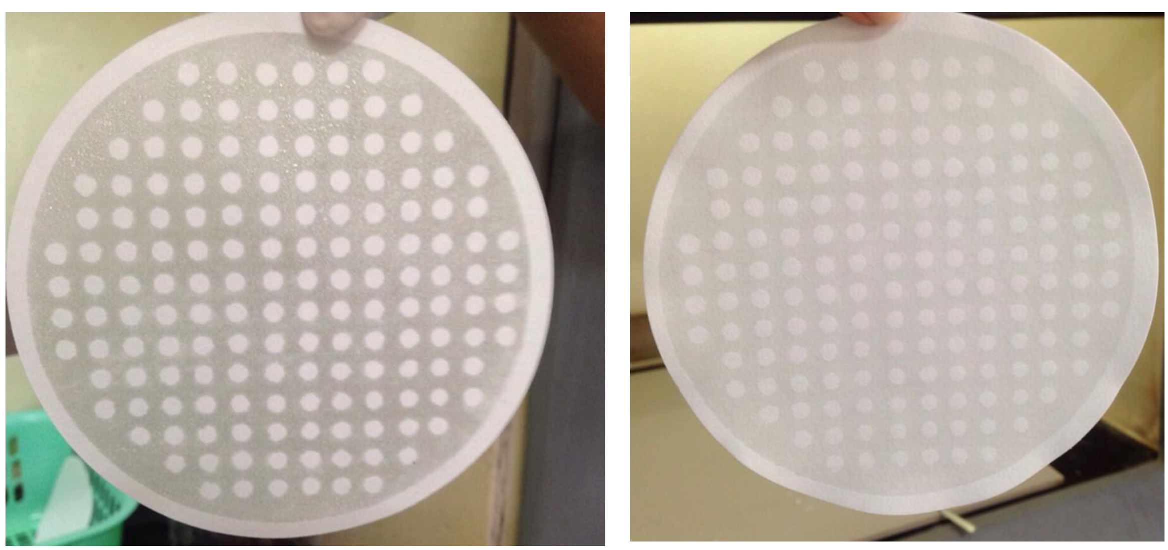
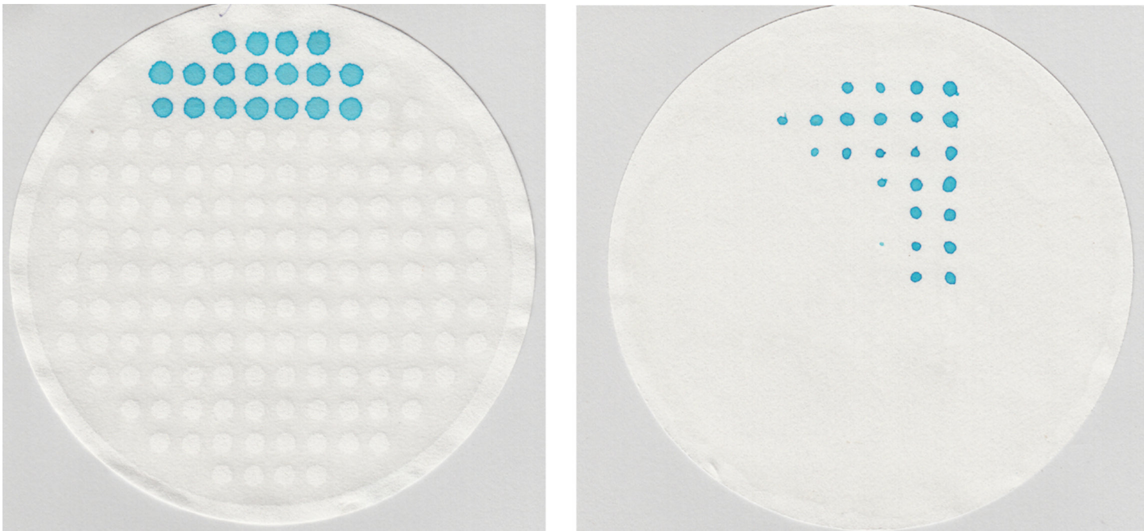


Figure S-2. Gray scale intensity measurement procedure using ImageJ.



(A) (B)

Figure S-3. Typical devices (A) immediately after fabrication using polymer-printing method and (B) after allow to dry. Right after fabrication, the wet area where the polystyrene solution penetrate through was observed and intact paper was still dry indicating that no toluene solution leaked into the intact paper during the fabrication.



10% 5%

Figure S-4 The fabricated paper using Whatman #1 with polystyrene solution at the concentration of 10% (left) and 5% (right) w/v. The results showed that 10% polystyrene solution (optimal concentration) gave well-define hydrophobic barrier on the paper where 5% polystyrene solution gave poor reproducibility of the pattern due to polystyrene solution spreading at low viscosity.

Before immerse	During immerse	Immediately after immerse	After dry

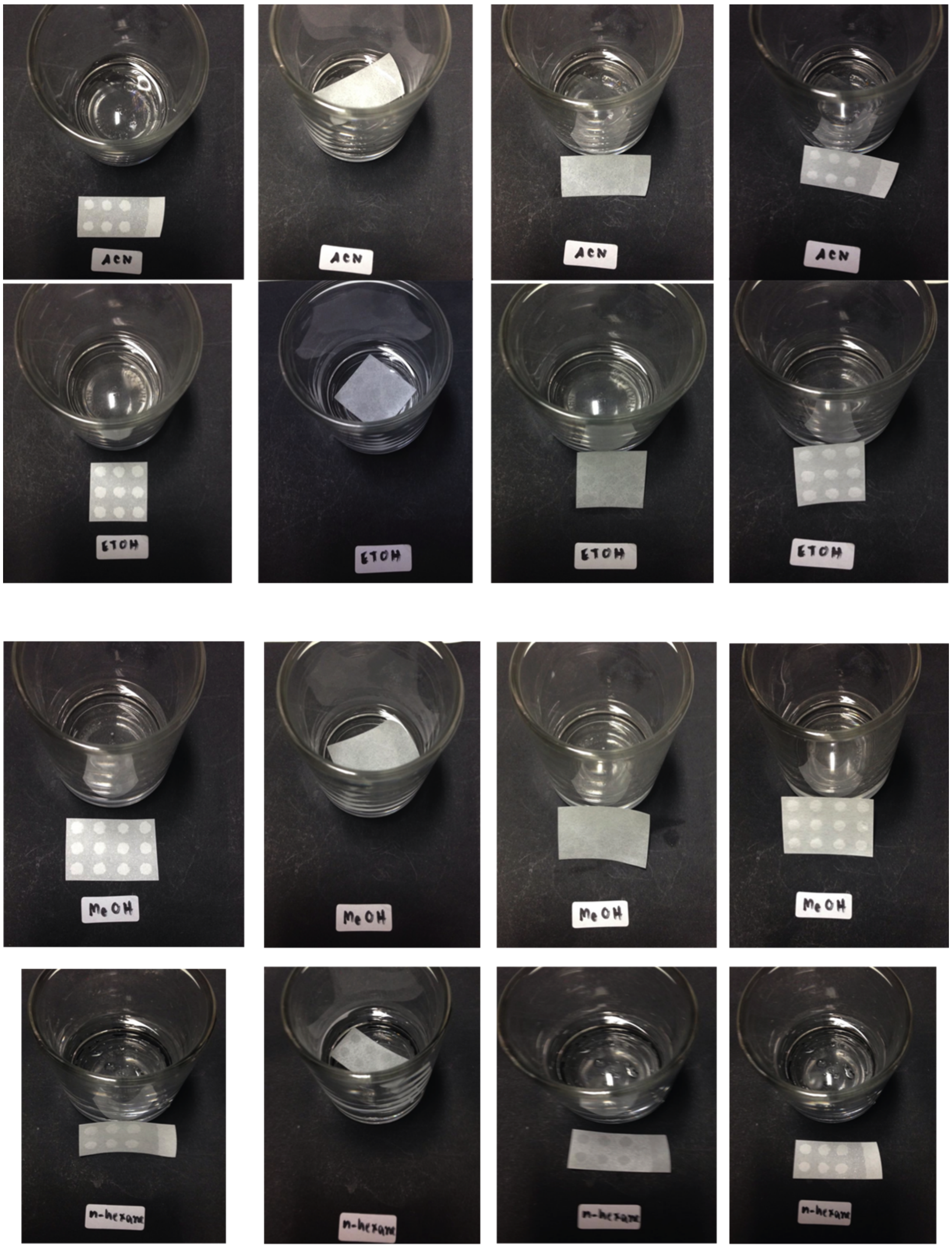
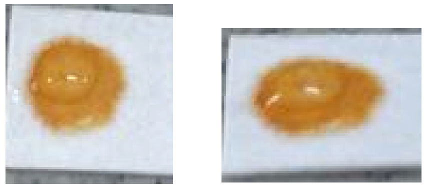


Figure S-5. Solvent resistivity testing of the μPAD fabricated using polymer-printing method. The tested solvent including acetonitrile (ACN), ethanol (EtOH), methanol (MeOH) and *n*-hexane. The results showed no damage of the pattern after immersing the device into the studied solvents.



Top view Side view

Figure S-6. Dropping of H_2O_2 onto a CeO_2-coated paper without the use of PEG. Some part of the H_2O_2 solution could wick into the paper and react with CeO_2 nanoparticles causing color forming. However, due to the hydrophobicity of the CeO_2 nanoparticles when presented as a thin film, some part of the solution still present as a drop .

List of the chemical equations previously proposed for the reaction of H_2O_2 and CeO_2 nanoparticles.

The proposed chemical equations of H_2O_2 and CeO_2 that could make the change of the nanoparticles color from colorless to yellow-orange are based on the change in oxidation state of mixed valence state of Ce^{3+} and Ce^{4+} in the nanoparticles to give more Ce^{4+} oxidation state upon the addition of H_2O_2. Below are list of possible chemical equations proposed previously.

Das, M., et al[1] proposed the chemical equation between H_2O_2 and CeO_2 as follows:

$H_2O_2 \rightarrow 2(HO^{\cdot})$

$$Ce_2O_3 + 2HO^{\cdot} \rightarrow 2CeO_2 + H_2O$$

The mechanisms proposed by Scholes, F. H., et al[2] were the formation of Ce^{3+} peroxo complexes such as $Ce(H_2O_2)^{3+}$ as an initial step, followed by deprotonation, oxidation and precipitation to form peroxo-containing Ce^{4+} species such as $Ce^{4+}(O_2)(OH)_2$ as follows:

$$Ce^{3+} + H_2O_2 \leftrightarrow Ce(H_2O_2)^{3+}$$

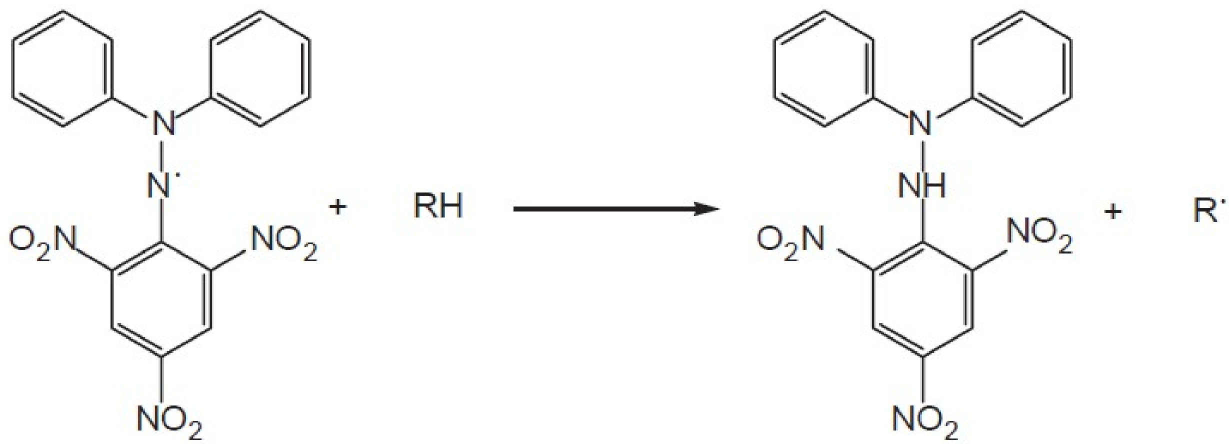
$$Ce(H_2O_2)^{3+} + OH^- \rightarrow Ce(HO_2)^{2+} + H_2O$$

$$Ce(HO_2)^{2+} + OH^- \rightarrow Ce(O_2)^{+} + H_2O$$

$$Ce(O_2)^{+} + \frac{1}{2}H_2O_2 \rightarrow Ce(O_2)^{2+} + OH^-$$

$$Ce(O_2)^{2+} + 2OH^- \rightarrow Ce(O_2)(OH)_2$$

Overall reaction: $$Ce^{3+} + \frac{3}{2}H_2O_2 + 3OH^- \rightarrow Ce(O_2)(OH)_2 + 2H_2O$$,,



DPPH$^{\bullet}$, Violet **DPPH, Yellow**

Figure S-7. Reaction scheme of DPPH radicals and antioxidant (RH). DPPH radicals is reduced by antioxidants changing its color from violet to yellow.

References

(1) Das, M.; Patil, S.; Bhargava, N.; Kang, J.-F.; Riedel, L. M.; Seal, S.; Hickman, J. J. *Biomaterials* **2007**, *28*, 1918.

(2) Scholes, F.; Soste, C.; Hughes, A.; Hardin, S.; Curtis, P. *Applied Surface Science* **2006**, *253*, 1770.