Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Highly Adhesive and Disposable Inorganic Barrier Films: Made from 2D Silicate Nanosheets and Water

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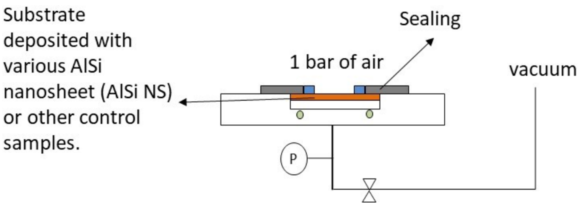

Figure S1. Device for measuring the air resistance (permeance).

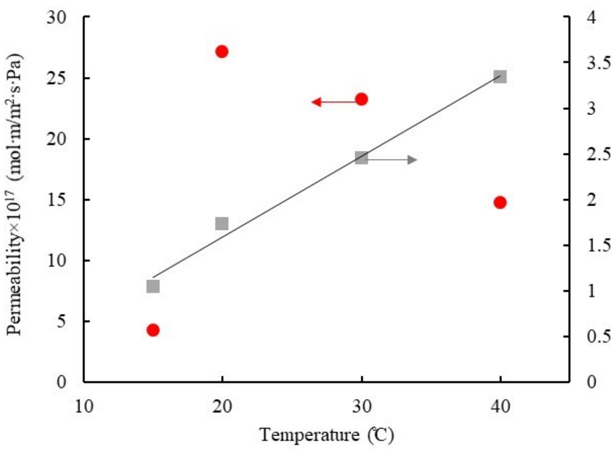

Figure S2. Oxygen permeability of saponite (red circles, left axis) and montmorillonite (gray squares, right axis) films with changing temperature from 15 to 40 ˚C with retaining humidity at 0% RH.

We note that the deposition conditions (concentration of the suspensions and spin rate) had very little effect on the air resistance of pure saponite film. To enhance the air resistance, we mixed the aluminosilicate nanosheet with PVA for the deposition. The air permeance of the hybrid materials was two orders of magnitude lower than a pure aluminosilicate nanosheet. More importantly, these hybridized materials also outperformed pure PVA at a high molecular weight by one order of magnitude. The extraordinary air resistance achieved by aluminosilicate nanosheets suggests they could be used as coatings to prevent the uptake of toxic gases, oxygen, or water vapor.

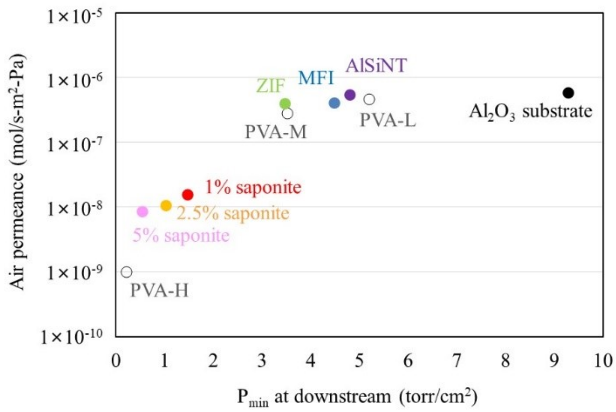

Figure S3. Air permeance of various types of films vs. P_{min} (the lowest pressure the downstream side could achieve) at the downstream side.

Fruit Preservation

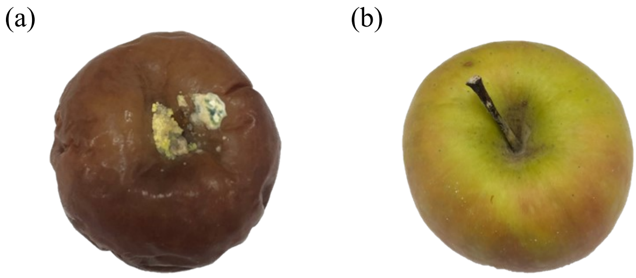

Figure S4. Photos of apples wrapped with cling wrap for 3 months at room temperature. (a) An apple without saponite film went brown, softened, and grew moulds, (b) The other apple coated with saponite film visually stayed in the initial state.

Quartz crystal microbalance sensor technique (QCM) [QCA922/SEIKO EG&G Co. Ltd]

To investigate the adsorptivity of the saponite film, a QCM sensor technique was utilized. An aqueous dispersion of 1.0 wt% saponite was sonicated with 0.1 wt% Nafion® binder (1 mL) for 10 min. 5.0 μL of saponite-Nafion® mixture was drop-coated onto the Au surface of the QCM electrodes and dried in an oven under vacuum overnight. The time dependence of the frequency was recorded during sequential injection of molecules. The adsorptivity of Nafion® was negligible (Figure S5).

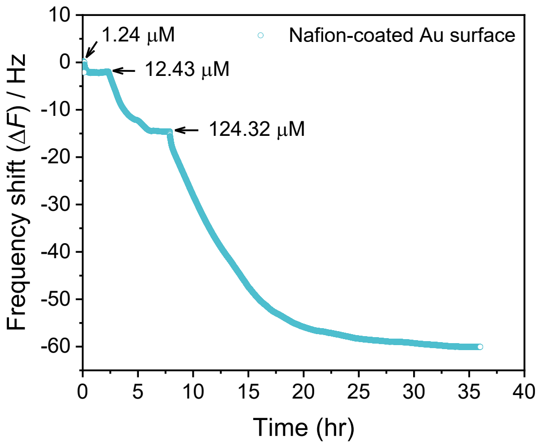

Figure S5. Time-dependent frequency shifts (Δ*F*s) upon adsorption of *trans*-β-farnesene to Nafion®-coated Au surface of the QCM.

It was expected that N_2 and O_2 would be difficult to detect with QCM analysis because both the molecular weight of the molecules and their adsorptivity are low. Thus, β-farnesene adsorption on the bare Au surface of the uncoated QCM electrode was studied after injection of various concentrations (1.24 μM, 12.4μM, and 124 μM). As the figure clearly shows, hardly any *trans*-β-farnesene vapor was detected on the bare Au surface of the QCM electrode, which showed a small response (ΔF = 1.76 Hz) at the low injection concentration of 1.24 μM. However, the frequency shift slightly increased with increasing injection concentration, and ΔF increased to 13.87 Hz and 44.96 Hz for *trans*-β-farnesene at 12.4μM and 124 μM, respectively. As clearly described, saponite has almost no sensing affinity when in contact with *trans*-β-farnesene. However, it was observed that saponite exhibits a slight increase in ΔF (ΔF = 46.54 Hz) when the injected concentration of *trans*-β-farnesene was increased to 124 μM. Furthermore, upon increasing the mass of the saponite-coated QCM electrodes from 0.78 μg to 2.55 μg, only a slight increase in the ΔF of *trans*-β-farnesene was observed and the *trans*-β-farnesene could not be quantitatively detected at the same concentration range as shown in Figure S6. These small Δ*F*s are not proportional to the adsorbed amount (Δm) and deviated from the Sauerbrey equation,[1] which shows the relation between ΔF (Hz) and Δm ($g{\cdot}cm^{-2}$) (1) upon increasing the concentration of injected *trans*-β-farnesene.

$$\Delta F = -\frac{2NF_0^2\Delta m}{\sqrt{\rho\mu}\;A} \text{.................(1)}$$

where N, F_0, ρ, μ, and A are the harmonic overtone, fundamental resonance frequency of the quartz crystal (Hz), density of the quartz (2.649 $g{\cdot}cm^{-3}$), elastic shear modulus (2.947 × 10^{11} $g{\cdot}cm^{-1}{\cdot}s^{-2}$), and the surface area (5 mm diameter, 0.196 cm^2), respectively. To estimate the mass of the saponite sample deposited on the QCM electrode, for example, Δ*F*s recorded after drop-coating of the saponite were 2238.6 and 7298.3 Hz; thus, the estimated mass amounts deposited were 3.98 $\mu g{\cdot}cm^{-2}$

(*ca.* 0.78 μg) and 13.01 μg·cm^{-2} (*ca.* 2.55 μg), respectively.

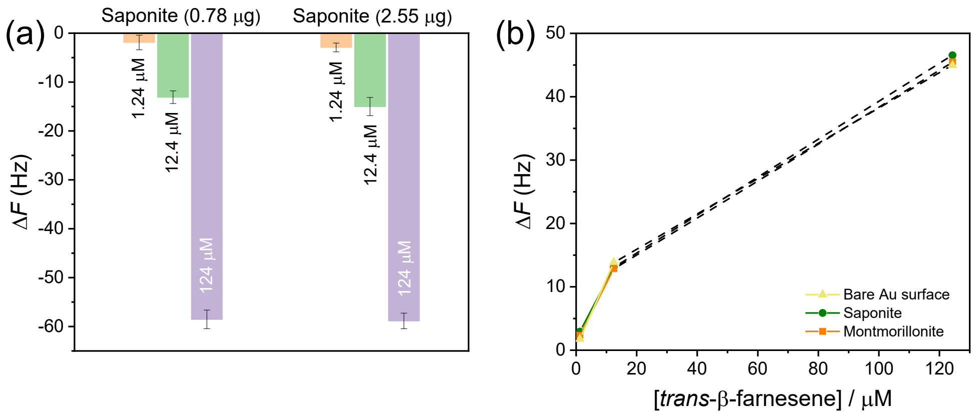

Figure S6. (a) Summary of Δ*F*s of the QCM sensor recorded for the saponite films with mass amounts of 78 μg and 2.55 μg upon injection of various *trans*-β-farnesene concentrations (1.24 μM, 12.4 μM and 124 μM). (b) Concentration-dependent frequency shifts (Δ*F*s) of the bare Au electrode, and saponite and montmorillonite films coated-QCM electrodes after contact with *trans*-β-farnesene at room temperature.

References

(1) N. L. Torad, H. El-Hosainy, M. Esmat, K. E. El-Kelany, R. Tahawy, J. Na, Y. Ide, N. Fukata, W. Chaikittisilp, J. P. Hill, X. Zhang, M. El-Kemary and Y. Yamauchi, Phenyl-modified carbon nitride quantum nanoflakes for ultra-highly selective sensing of formic acid: A combined experimental by QCM and density functional theory study, *ACS Appl. Mater. Interfaces*, 2021, **13**, 48595–48610.