SUPPORTING INFORMATION

Synthesis Scheme and Characterization. The synthetic scheme leading to the desired amphiphilic probe molecules is depicted in Scheme S1. $^1$H NMR (400 MHz, CDCl$_3$): $\delta$ 0.88 (t, $J = 7.0$ Hz, 3H, CH$_3$), 1.26 – 1.37 (m, 16H, 8x CH$_2$), 1.63 (p, $J = 7.3$ Hz, 2H, CH$_2$), 2.58 (t, $J = 7.6$ Hz, 2H, CH$_2$), 6.41 (s, 1H, ArH (phenyl)), 7.21 (s, 1H, ArH (phenyl)), 7.32 (d, $J = 3.4$ Hz, 1H, thiazole), 7.88 (d, $J = 3.4$ Hz, 1H, thiazole), 5.02 (s(b), (OH) 2H). $^{13}$C NMR (100 MHz, CDCl$_3$): $\delta$ 14.1 (CH$_3$), 22.7 (CH$_2$), 29.0 (CH$_2$), 29.4 (CH$_2$), 29.5 (CH$_2$), 29.6 (CH$_2$), 29.6 (CH$_2$), 29.7 (CH$_2$), 29.7 (CH$_2$), 29.7 (CH$_2$), 31.9 (CH$_2$), 76.2 (C), 103.1 (C), 119.6 (C), 132.3 (CH), 138.1 (CH), 143.2 (CH), 158.6 (C), 167.1 (C-OH), 178.4 (C-OH). CHNS Analysis (%, Calcd: 64.78 C, 7.97 H, 10.79 N, 8.22 S; %, Found: 64.79 C, 8.01 H, 10.75 N, 8.20 S).

Scheme S1. Synthesis route for 4-n-dodecyl-6-(2-thiazolylazo)-resorcinol (DTAR)

The chemically synthesized probe molecules were film spread and transferred onto a precleaned glass substrate, to form a two layer molecular assembly (D$_2$). The probe structural features were characterized by attenuated total reflectance (8000 model) FT-IR spectrometer, with a KRS-5 prism (Figure S1). Spectral bands observed at 2914 and 2855 cm$^{-1}$ were ascertained to the stretching vibration frequencies of –CH$_3$ and –CH$_2$ units. Information on probe molecular orientation wasn’t predictable from the observed CH$_2$ stretching, shown below. The strong band observed at 2350 cm$^{-1}$ correspond to the Si-H stretching vibration and also broad peaks observed in the range of 3350-3050 cm$^{-1}$ corresponds to Si-OH unit, which coincides with the O-H stretching vibration. Bands observed at 1633 and 1392 cm$^{-1}$ are correlated with the conjugated aromatic -C=C- and -N=N- stretching vibrations. A variety of peaks
observed from 1305 to 1050 cm⁻¹, were mainly ascertained to the vibrational frequencies of the thiazole ring.

**Figure S1.** ATR-FT-IR spectra of a 2 layer DTAR molecular assembly mounted on a glass substrate.

**Ion-Sensing and pH Factor.** The influential role played by solution pH on cadmium sensing has been discussed earlier. The degree of cadmium chelation at different sample pH, using various buffer solutions (KCl-HCl for pH 1-3; AcONa-AcOH for pH 4-6; MOPS-NaOH for pH 6-8; CHES-NaOH for pH 9-11), on a D16-PVOC1 film assembly was studied. Figure S2, depicts the level of cadmium signal response as a function of pH (at 607 nm), where the pH range (5.5-8.25) has been short-listed, to focus narrowly on the possible regions of cadmium response. It is interesting to observe that the ion-sensing performance of the film probe is mostly around the regions of mild acidity to slight alkalinity, without prominent response at low solution pH. This behavior has been attributed to the poor acidic (pKₐ) property of the chromoionophore (DTAR), owing to its long alkyl chain.
**Figure S2.** pH dependent cadmium signal response on a 16 layered DTAR membrane, covered with a PVOC monolayer, on glass substrate.

**Isotherm Plot for Probe-Polymer Hybrid.** Isotherm plots for DTAR:PVOC mixed ratios, reveal a gradual raise in the mean molecular area (Å²), with decreasing DTAR ratio against an increasing PVOC content. The isotherm plots (Figure S3A) reveal the formation of stable condensed films at the air-water interface, with a relatively steep rise until ~38 mN/m, demonstrates a close packing of the molecules. The area per molecule of the hybrid composite, which is obtained by extrapolation of the rising portion of the isotherm, ranges between 37.3-46.7 Å², from 90:10 to 10:90 (DTAR:PVOC) ratios. However, a closer resemblance to DTAR isotherm plot was observed at 90:10 mixed ratios, and at 20:80 mixed ratios, the isotherm resembles PVOC. This profile helps in predicting a possible alternate layer-by-layer deposition pattern of DTAR & PVOC monolayers with 60:40 & 40:60 mixed ratios. Isotherm plots for DTAR:PVS mixed ratio, produced an opposite trend to that of DTAR:PVOC ratios, but their trends also seems to suggest a possible alternative arrays of DTAR and PVS layer (Figure S3B).
Figure S3. (A) The surface pressure ($\pi$) – area (A) isotherm plots for various mixed ratios of DTAR and PVS monolayers. (B) Isotherm plots for various composition of DTAR:PVOC ratios measured at 20°C.

**Stability of DTAR-PVOC L-B Hybrid Ratios.** The stability of L-B hybrid ratio of probe-polymer composites has been studied and discussed earlier in the main text, and a plot depicting their durability in 2 M HCl, is shown in Figure S4. Also, the relative signal intensity of the hybrid film composites, to that of a D16 film assembly at $\lambda_{\text{max}} \approx 540$ nm, with an absorbance $\approx 0.158$ was fixed as 100% values was compared. However, similar mixed ratios studies for DTAR:PVS, were appreciable in their % signal intensities but found to exhibit $>10\%$ loss on its stability even at 70:30 mixed ratios, thus preventing the idea of using PVS film layers in the process of sensor fabrication.
**Figure S4.** Sensor durability test for various L-B hybrid ratios in 2M HCl solution and their relative stability correlated in terms of their signal intensity at $\lambda_{\text{max}} \sim 540$ nm.

**Influence of Surfactants on Sensor Stability.** As mentioned earlier in the text, surfactants are used in various applications especially in the production of cosmetics, soaps, detergents, dyes etc., that finds its way into water resource through domestic and industrial activities. Since L-B films are prone to deteriorate in the presence of detergents over a period of time, the influence of various surfactants (cationic, anionic or non-ionic) on the stability of fabricated film sensor was studied, at their maximum tolerance limit. For this, time dependent film durability study has been performed with a series of D22-PVOC sensor strip, in the presence of commonly employed surfactants, as shown in Figure S5. The relative changes in the sensor absorbance were measured at $\lambda_{\text{max}} 539$ nm, which showed insignificant change even up to 60 minutes of equilibration. The presence of protective polymer coating ensured a stable film membrane that could withstand surfactants of concentrations even exceeding beyond their permitted or observed level in environmental samples. The abbreviation for the surfactants employed is shown below and their tolerance values in milli-molar concentrations are denoted in parentheses.

TN101 - Triton N-101 (0.328 mM); TX100 - Triton X-100 (0.158 mM); TAAC – Tetraamylammonium chloride (0.247 mM); TEAC - Tetraethylammonium chloride (0.538 mM); DDAC - Dilauryldimethylammonium chloride (0.303 mM); CTAB - Cetyltrimethylammonium bromide (0.217 mM); DDAB - Dilauryldimethylammonium bromide (0.173 mM); CTAC - Cetyltrimethylammonium Chloride (0.244 mM); SDS – Sodium dodecyl sulphate (0.154 mM).
Figure S5. Stability profile of D22-PVOC1 sensor assembly, amidst surfactants of different variety.