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Supplementary information

Water-processable, biodegradable and coatable aquaplastic from engineered biofilms

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Supplementary Materials

Water-Processable, Biodegradable and Coatable Aquaplastic from Engineered Biofilms

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Supplementary Figures 1-17
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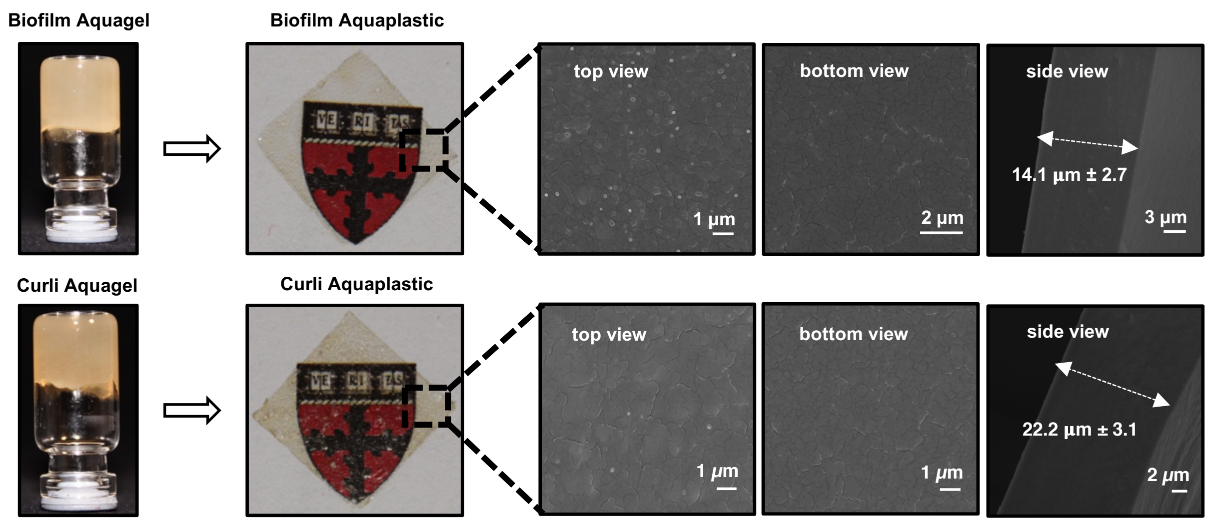
Amino acid sequence of the CsgA domain: GVVPQYGGGGNHGGGGNNSGPNSELNIYQYGGGNSALALQTDARNSDLTITQHG GGNGADVGQGSDDSSIDLTQRGFGNSATLDQWNGKNSEMTVKQFGGGNGAAVDQ TASNSSVNVTQVGFGNNATAHQY
Amino acid sequence of linker: GGSGSSGSGGSGGGSGSSGSGGSGGGSGSSGSGGSG
Amino acid sequence of TFF2 domain: EKPSPCQCSRLSPHNRTNCGFPGITSDQCFDNGCCFDSSVTGVPWCFHPLPKQES DQCVMEVSDRRNCGYPGISPEECASRKCCFSNFIFEVPWCFFPKSVEDCHY

Supplementary Table 1. **Amino acid sequences of engineered curli fibers domain that create aquaplastic**.

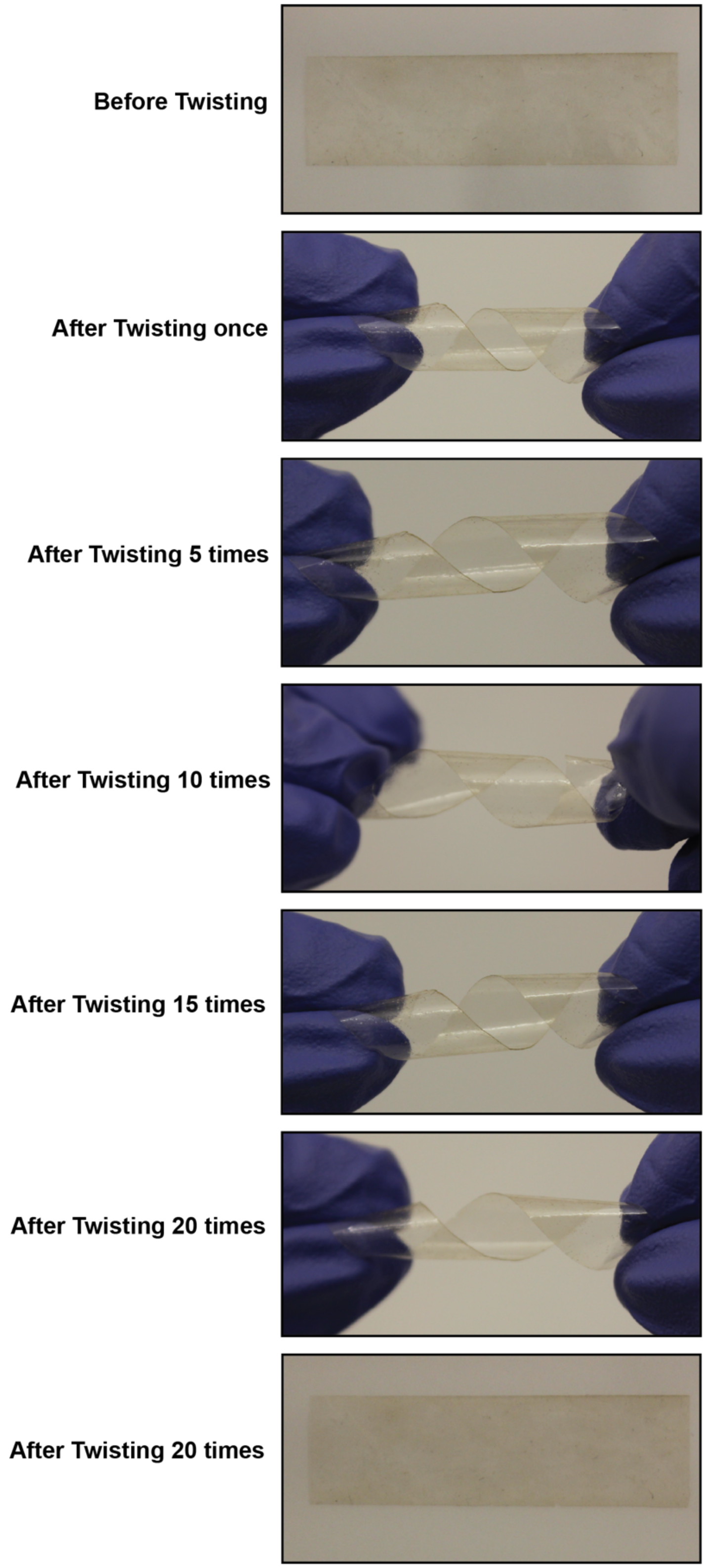
Material	Young's modulus (GPa)	Ultimate tensile strength (MPa)	Yield strength (MPa)
Biofilm aquaplastic	2.2 ± 0.7** 1 ± 0.2***	18 ± 5***	55 ± 36**
Curli aquaplastic	4.3 ± 0.9** 1.2 ± 0.2***	29 ± 5***	84 ± 47**
Low-density polyethylene (LDPE)	0.11-0.45*	5-21*	5-15*
High-density polyethylene (HDPE)	0.8*	20-37*	16-35*
Polycarbonate	2-2.6*	50-70*	60-70*
Polystyrene	3-3.5*	30-100*	
Polyethylene terephthalate (PET)	2-2.7*	55-80*	27-38*
Polypropylene	1.5-2*	20-40*	12-43*
Polytetrafluoroethylene (PTFE)	0.4-1.4*	10-25*	14-25*
Polyvinylchloride (PVC)	2.4-4.1*	52*	40-55*
Polyvinyl Alcohol (PVA)	0.1-2.5*	15-50*	24-37*
Polylactic acid (PLA)	2.3-4.2*	25-50*	35-40*
Polyhydroxyalkanoate (PHA)	0.2-3.5*	11-40*	6-21*

Supplementary Table 2: List of mechanical properties of aquaplastics, petrochemical plastics and bioplastics.[1-3]

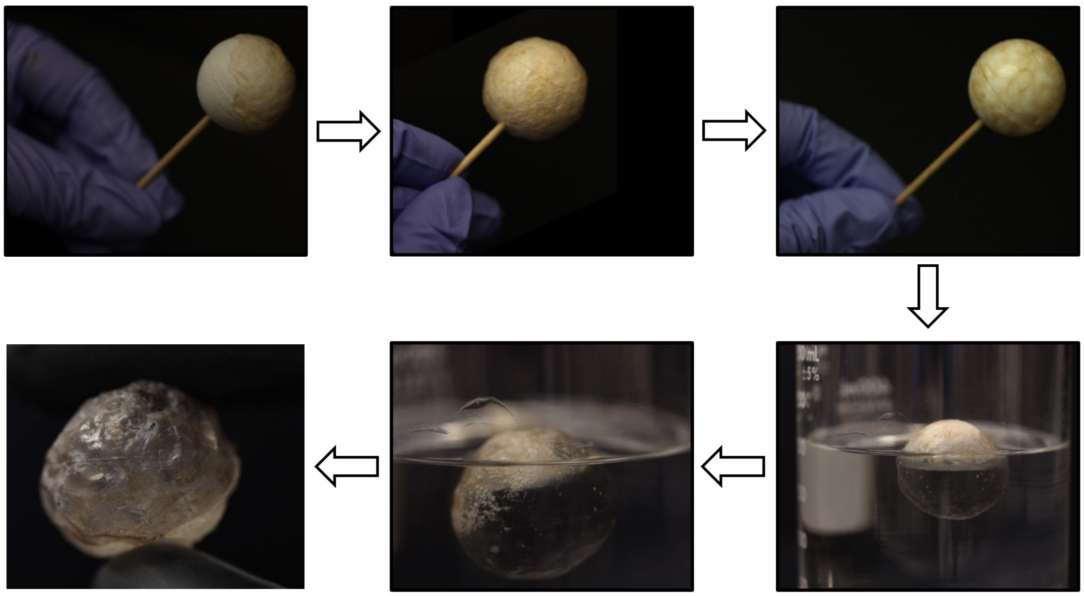
* The values depend on manufacturing process and purity or composition
** Nanoindentation data – present work
*** Tensile data – present work



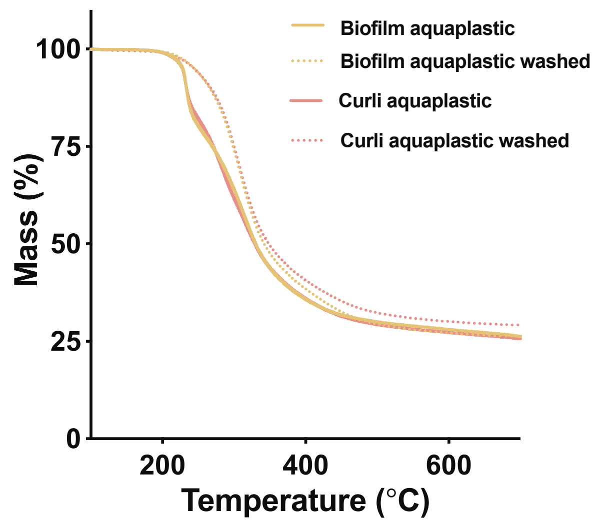
Supplementary Figure 1. Fabrication of aquaplastic and its images. Optical images show biofilm aquagel and curli aquagel as a precursor of biofilm aquaplastic and curli aquaplastic of 1 cm^2 lateral dimensions. Field Emission Scanning Electron Microscope (FESEM) images show top, bottom and side view of biofilm aquaplastic and curli aquaplastic. The values in FESEM side view images indicate topographical thickness of biofilm aquaplastic and curli aquaplastic.



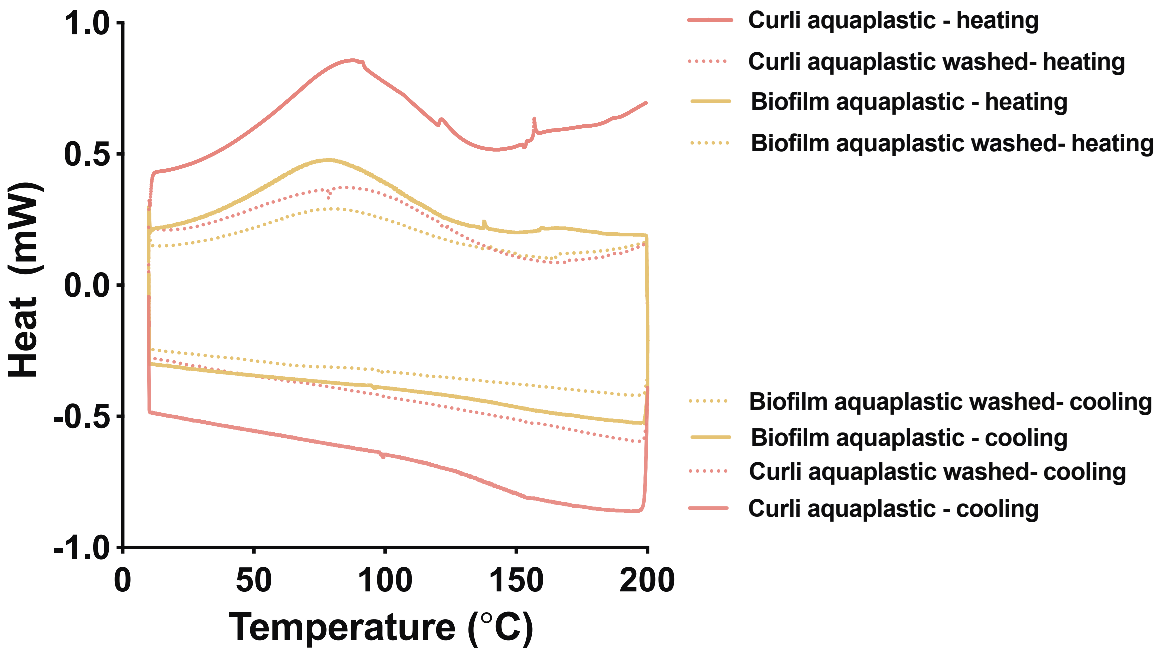
Supplementary Figure 2. Optical images show repeated twisting of biofilm aquaplastic film of 4 cm X 1 cm.



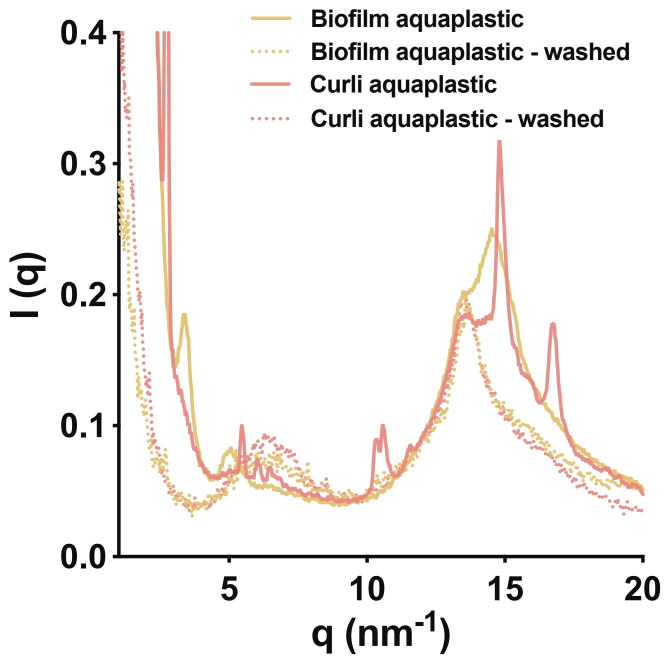
Supplementary Figure 3. 3D molding of aquaplastic. Spherical polystyrene mold (5 cm diameter) was coated with biofilm aquagel, dried in ambient conditions and immersed in chloroform to selectively dissolve polystyrene to form 3D aquaplastic.



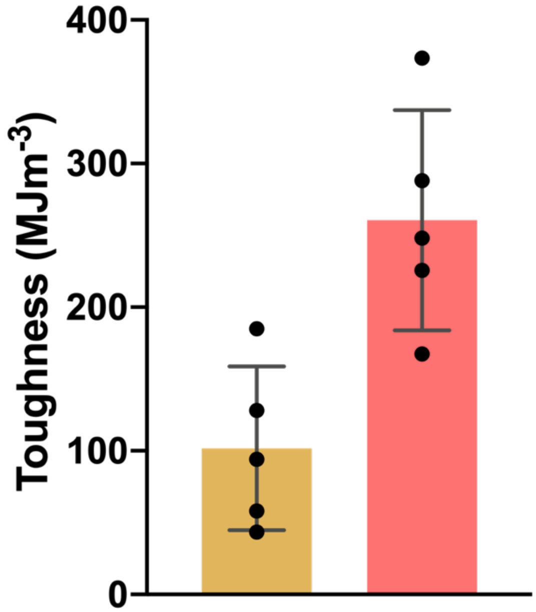
Supplementary Figure 4. Thermogravimetric analysis (TGA) of biofilm aquaplastic and curli aquaplastic. TGA thermograms of biofilm aquaplastic and curli aquaplastic before and after washing with water.



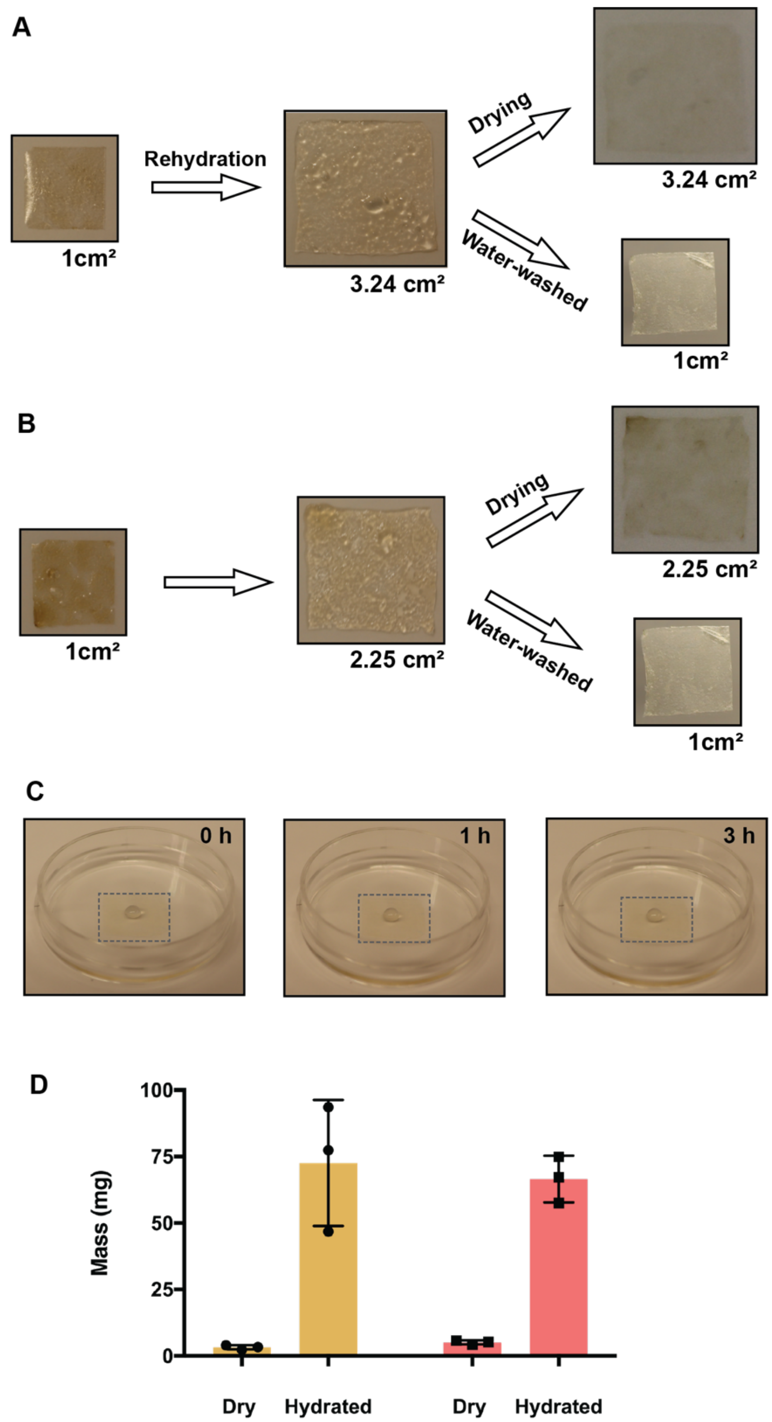
Supplementary Figure 5. Differential scanning calorimetry studies of biofilm aquaplastic and curli aquaplastic. DSC thermograms show the heating cycle and cooling cycle of aquaplastic before and after washing with water.



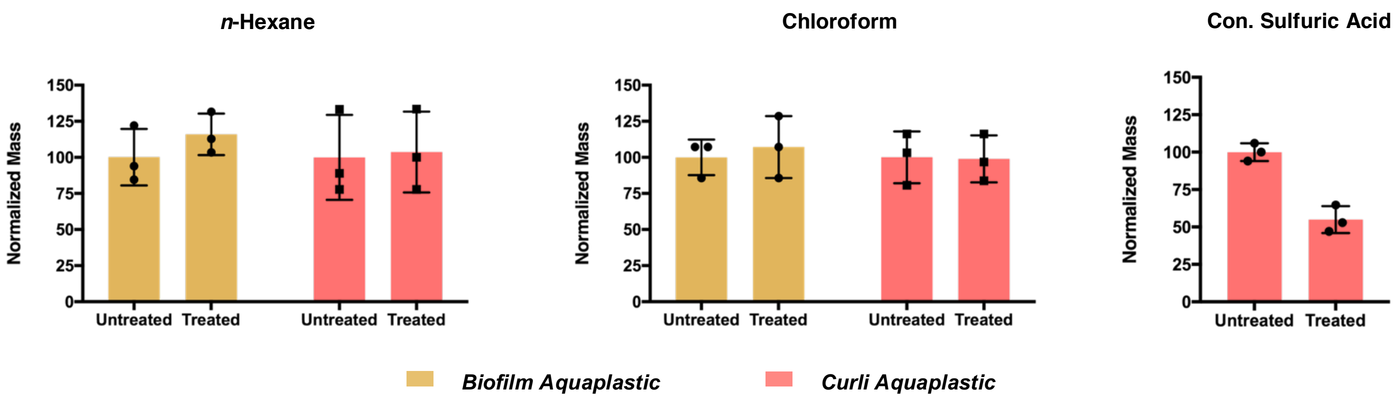
Supplementary Figure 6. Wide-Angle X-ray Scattering (WAXS) studies of biofilm aquaplastic and curli aquaplastic. WAXS intensity profile of biofilm aquaplastic and curli aquaplastic before and after washing with water.



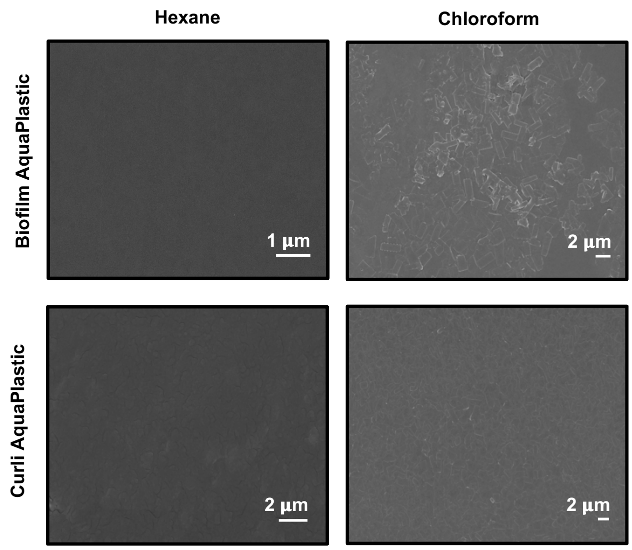
Supplementary Figure 7. Tensile toughness (mean and the standard deviation) of biofilm aquaplastic (yellow) and curli aquaplastic (red) obtained by tensile tests.



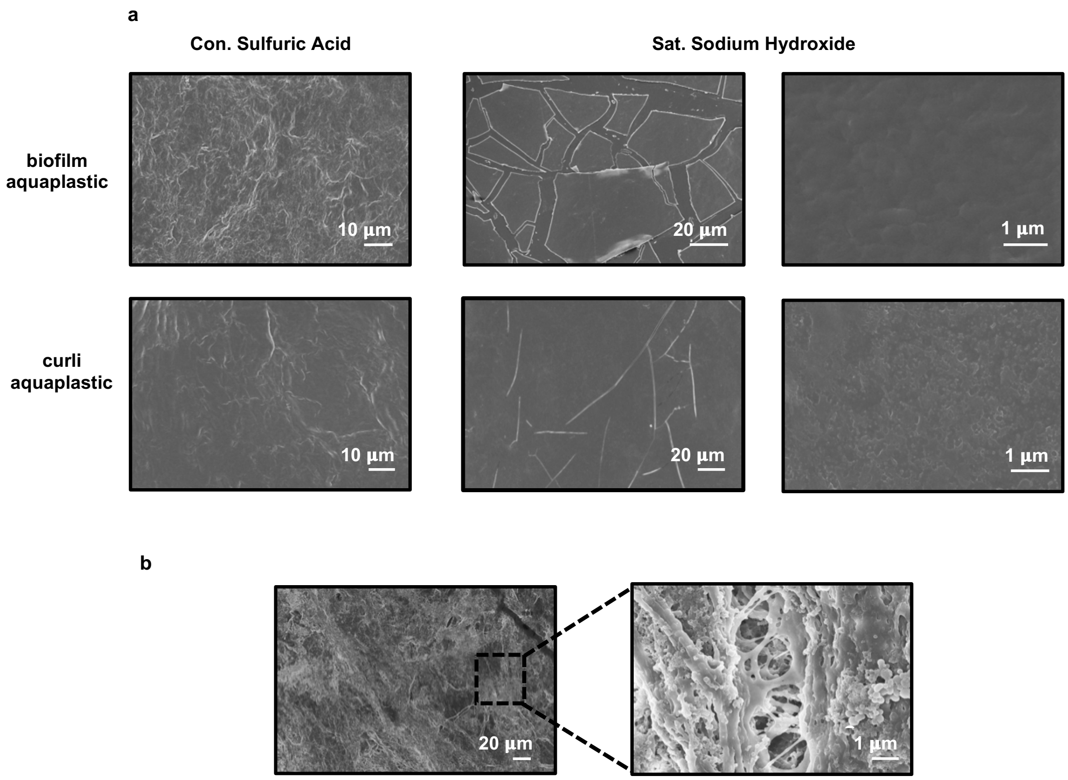
Supplementary Figure 8. Rehydration capabilities of biofilm aquaplastic and curli aquaplastic Rehydration of **A.** Biofilm aquaplastic and **B.** Curli aquaplastic. Biofilm aquaplastic and curli aquaplastic films of 1 cm^2 dimensions when added with water get rehydrated and swell to 3.24 cm^2 and 2.25 cm^2. If air dried at this point then they retain the same dimensions, but if washed in excess water then they shrink back to the original dimension of 1 cm^2. **C.** Water washed aquaplastic (1 cm^2 lateral dimensions) is hydrophobic and do not wet the surface. **D.** Plot shows normalized rehydrated mass change (mean and the standard deviation) for biofilm aquaplastic (yellow) and curli aquaplastic (red).



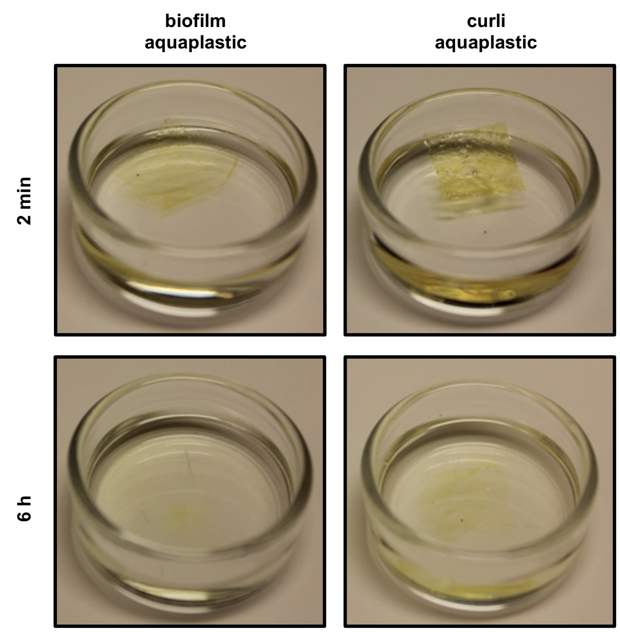
Supplementary Figure 9. Weight change of aquaplastic after 24 h exposure to chemicals. Weights (mean and the standard deviation) of aquaplastic films before (untreated) and after (treated) incubation in organic solvents (*n*-hexane, chloroform) and strong acid (98% sulfuric acid) for 24 h exposure.



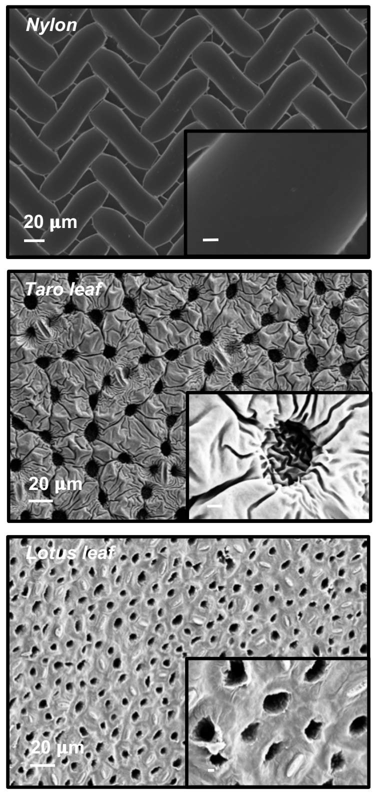
Supplementary Figure 10. Morphological studies of aquaplastic. FESEM images of biofilm aquaplastic and curli aquaplastic after 24 h incubation in n-hexane and chloroform.



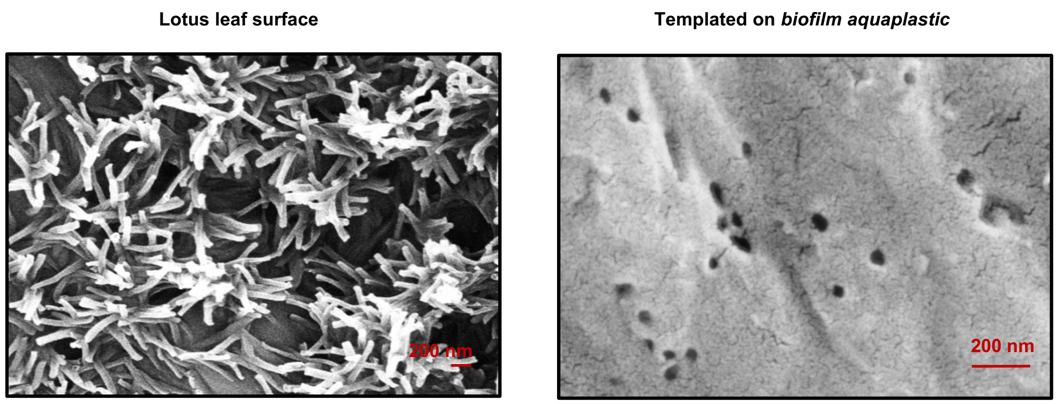
Supplementary Figure 11. Morphological studies of aquaplastic. FESEM images of **a**. Biofilm aquaplastic and curli aquaplastic after 24 h incubation in concentrated sulfuric acid (98%) and saturated (18 M) sodium hydroxide; **b.** Curli aquaplastic after 6 h incubation in concentrated nitric acid (70%).



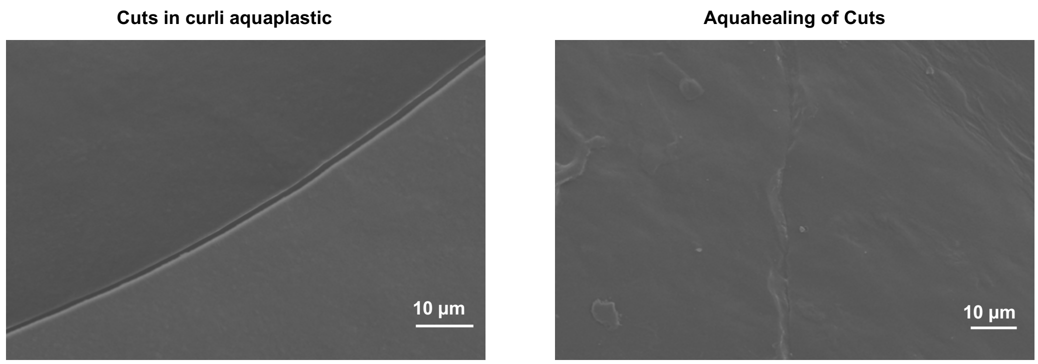
Supplementary Figure 12. Optical images of 1 cm^2 biofilm aquaplastic and curli aquaplastic fully immersed in the concentrated nitric acid (70%).



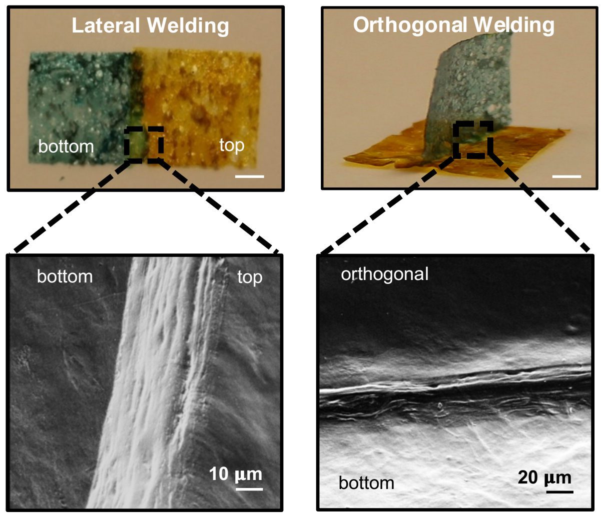
Supplementary Figure 13. Curli aquaplastic templating. FESEM images showing the patterns on curli aquaplastic obtained by templating curli aquagels on nylon, taro leaf (dorsal) and lotus leaf (ventral) surface. Inset scale bar 2 µm.



Supplementary Figure 14. Nanoscale pattern on biofilm aquaplastic. FESEM images show nanoscale features of lotus leaf's wax crystals templated on biofilm aquaplastic by ambient drying of biofilm aquagel on lotus leaf.



Supplementary Figure 15. Aquahealing of curli aquaplastic. Cuts in aquaplastic (left) was healed by adding water in place of cuts to form a continuous surface (right).



Supplementary Figure 16. Aquawelding of curli aquaplastic. Optical and FESEM images of two pieces of aquaplastic that were welded laterally or orthogonally by adding water. Top row: scale bar 0.5 cm.

a

b

Supplementary Figure 17. Optical images of engineered curli biofilms. **A.** *E. coli* with wild-type CsgA fibers, **B.** *E. coli* with engineered CsgA-TFF2 fusions; do not form crack free films in the absence of sodium dodecyl sulfate (SDS) upon drying, which emphasizes the role of SDS as a plasticizer in forming aquaplastic. Scale bar 1 cm.

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2 Massey, L. K. *Film properties of plastics and elastomers: a guide to non-wovens in packaging applications* (William Andrew Inc, 2004).

3 http://www-materials.eng.cam.ac.uk/mpsite/interactive_charts/strength-toughness/NS6Chart.html