

Electronic supplementary information

Natural flexible and responsive 2D photonic material with micro-sandwich structure

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Materials and methods

The samples were prepared and observed as described in the main article.

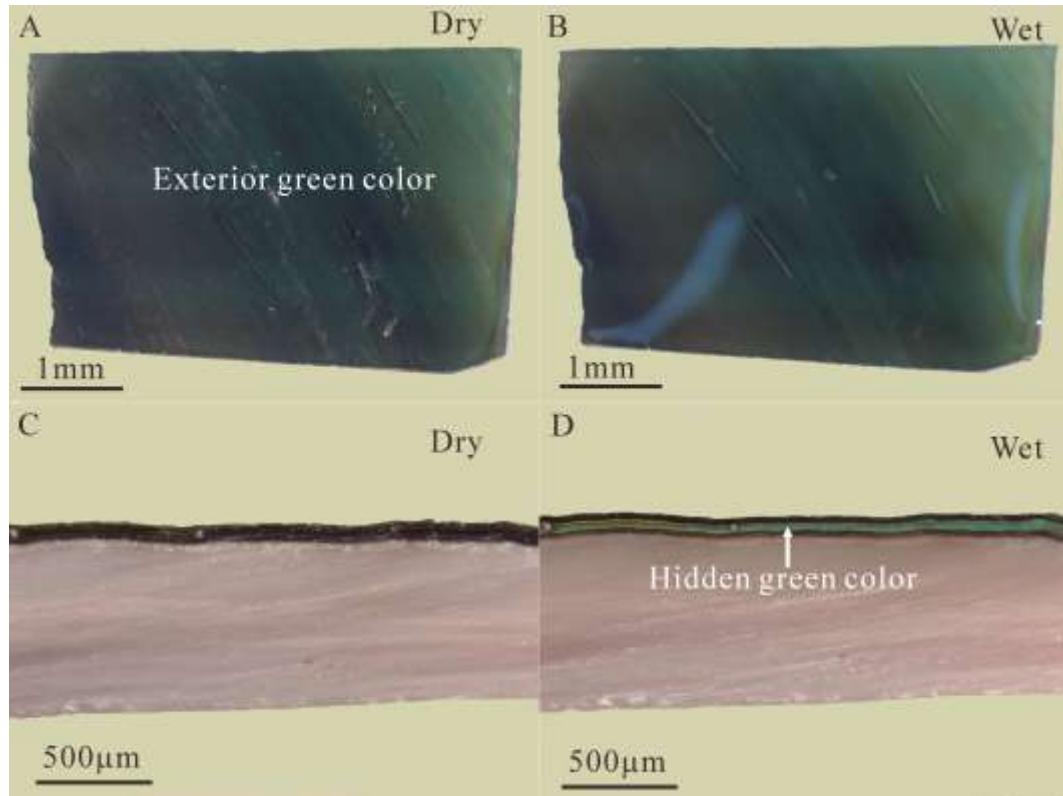


Figure S1. Optical images. (A) and (B) Top view of the exterior surface of shell fragment near the shell edge at wet and dry state, respectively. (C) and (D) Cross-sectional view of the fragment in Fig. A and B, respectively.

Please note:

(1) Fig. S1 shows two types of green colors appearing in shell fragment, i.e., the exterior and hidden green colors. The former is humidity-independent, namely, both the dry and wet periostracum show identical green colors. However, the latter is humidity-independent, namely, it only appears in the wet periostracum but disappears in the dry one.

(2) Fig. S1B shows two small area with different color from exterior green color, which is caused by water film.

(3) The exterior green color occurs on the surfaces of the periostracum and can be observed directly. However, the hidden green color not on the surfaces of the periostracum but within it. Therefore, it cannot be observed unless the periostracum are broken.

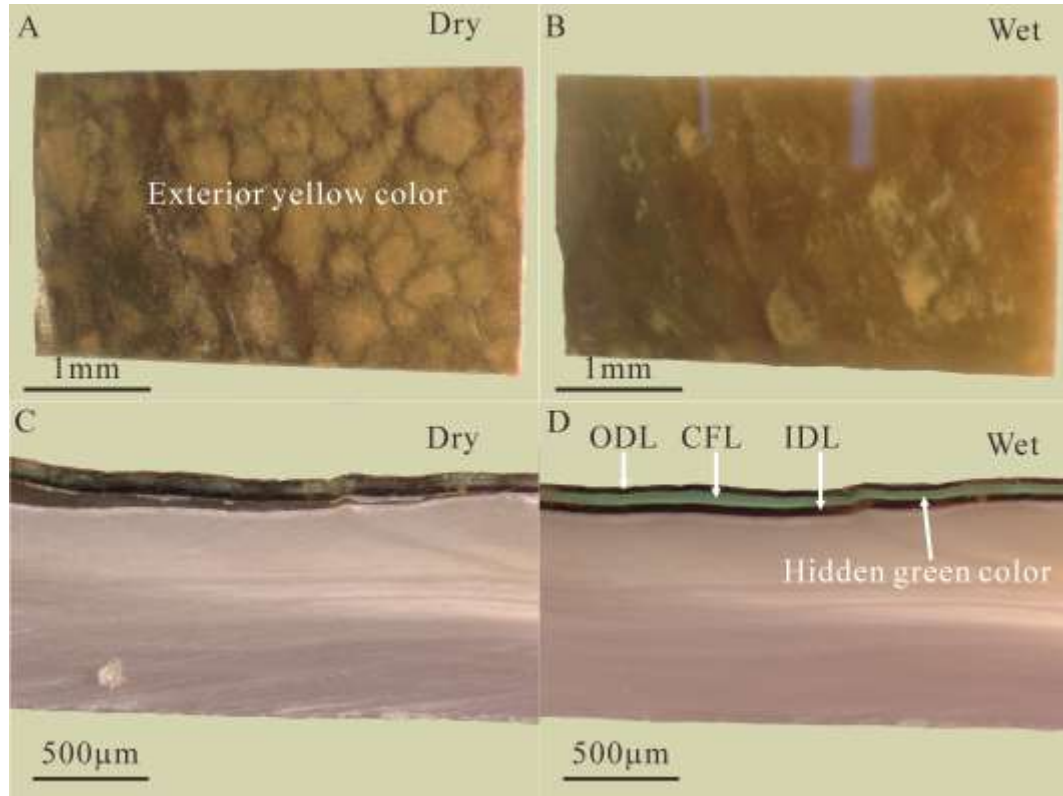


Figure S2. Optical images. (A) and (B) Top view of the exterior surface of shell fragment near the shell centre at wet and dry state, respectively. (C) and (D) Cross-sectional view of the fragment in Fig. A and B, respectively. ODL: outer dense layer, CFL: central fibrous layer, IDL: inner dense layer.

Please note:

(1) Fig. S2 shows two types of colors appearing in shell fragment, i.e., the exterior yellow and hidden green colors. The former is humidity-independent, namely, both the dry and wet periostracum show identical yellow colors. However, the latter is humidity-independent, namely, it only appears in the wet periostracum but disappears in the dry one.

(2) Fig. S2B shows two small area with different color from exterior yellow color, which is caused by water film.

(3) Fig. S2 shows the periostracum with exterior yellow color also has trilayered sandwich structure in cross section, of which, the outer and inner layer show uniform dark brown color, while the central layer bright nonuniform green colors (i.e., hidden green color).

(4) These three layers are called outer dense layer (ODL), inner dense layer (IDL), and central fibrous layer (CFL), respectively, based on the optical and SEM observation as will be detailed in Fig. S3.

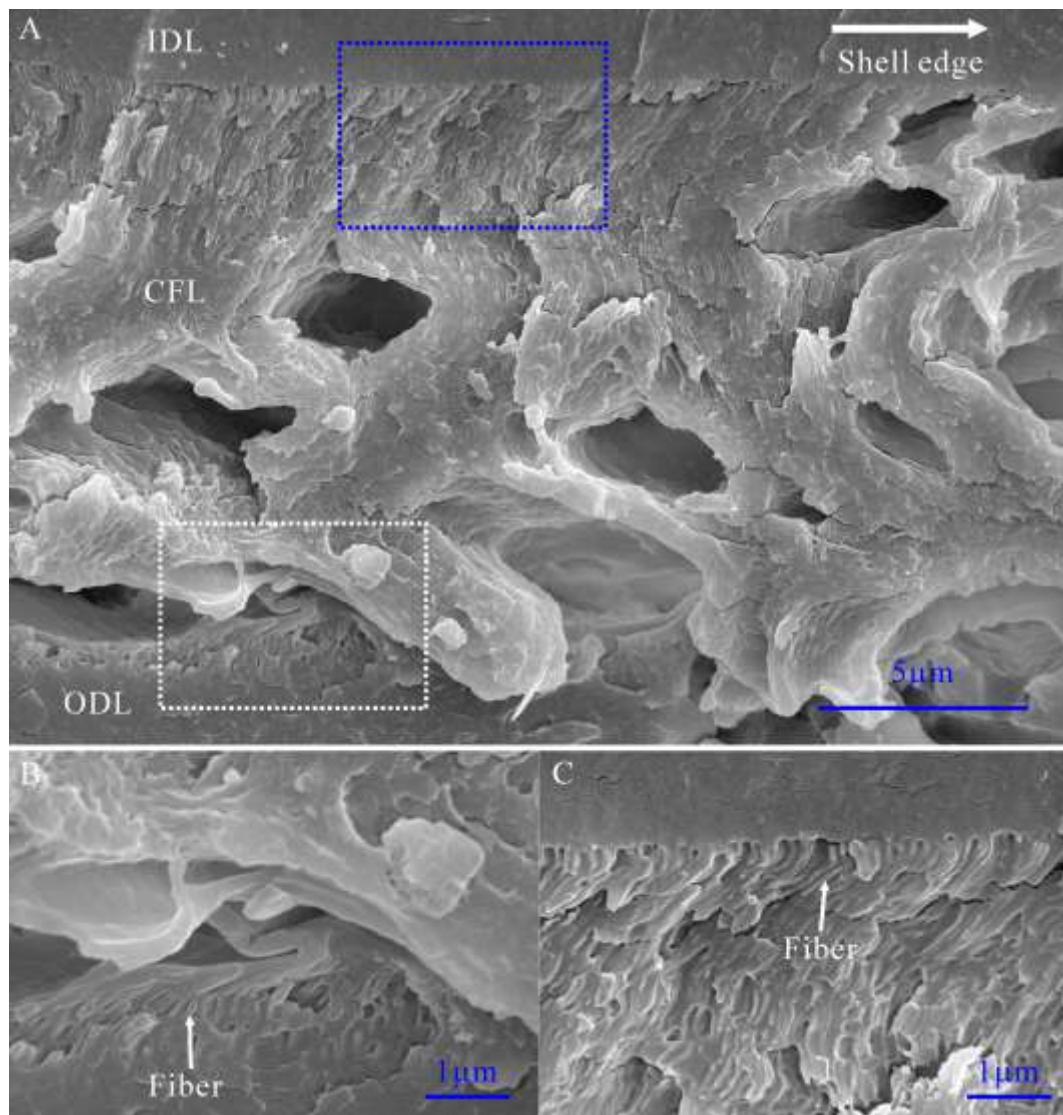


Figure S3. SEM images of undamaged periostracum near the shell centre in cross sectional fractured along line a - a' in Fig. 1A. (A) Full view, (B) and (C) Magnific view of white and blue dashed box in A, respectively. IDL: inner dense layer, CFL: central fibrous layer, ODL: outer dense layer.

Please note that:

(1) Fig. S3 shows the periostracum near the shell centre in cross-section cut along the line a-a' in Fig. 1A. The periostracum also consists of three layers (IDL, CFL, ODL) (Fig. S3A), similar to those near the shell edge as described in main article.

(2) The characterization of fibres is also similar to those near the shell edge as described in main article.

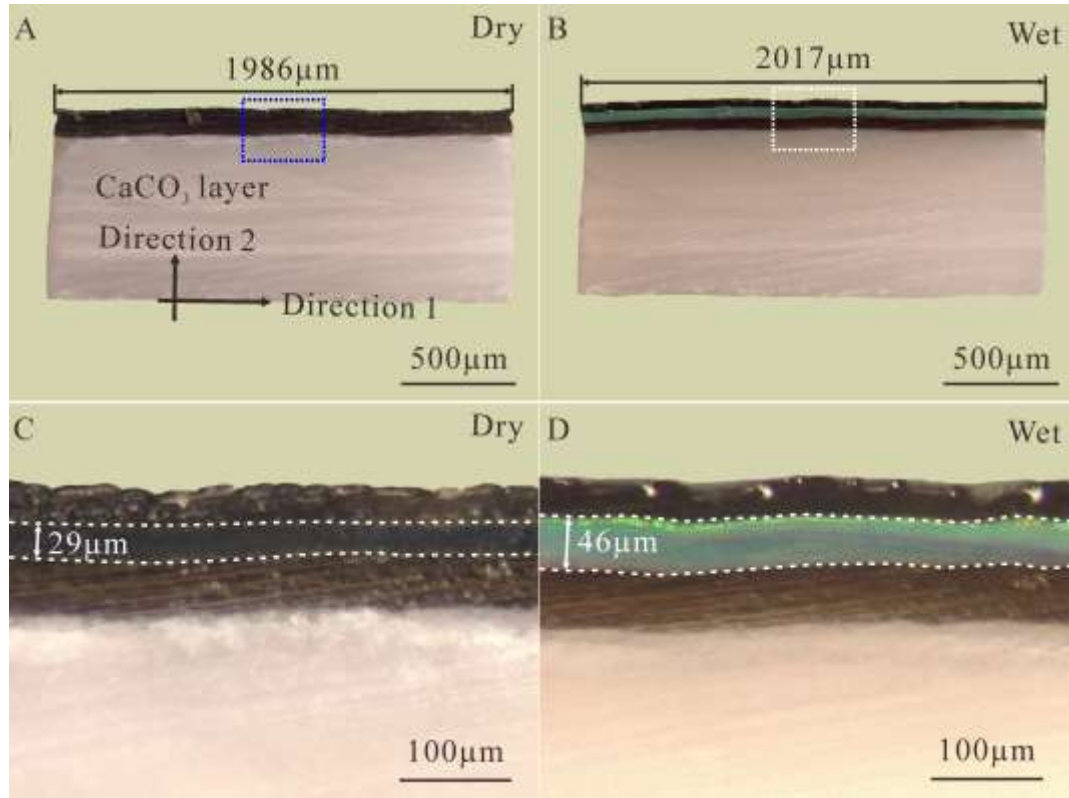


Figure S4. Optical images. (A) and (B) Cross-sectional view of a fragment at wet and dry state, respectively. (C) Magnified blue dashed box in A. (D) Magnified white dashed box in B.

Please note that:

(1) In direction 1, Fig. S4A and B show that: (a) the length of ODL appear near identical at dry and wet state, (b) the length of IDL must be identical and remain unchanged at dry and wet state due to attach to the hard CaCO₃ layer. In this case, the space between fibers is constant.

(2) In direction 2, Fig. S4C and D show that: (a) the thickness of CFL is non-identical at dry and wet state, which is shrinking ~37% at dry one, (b) the thickness of ODL and IDL appear identical at dry and wet state.