

New application field of polyethylene oxide:  
PEO nanofibers as epoxy toughener for effective CFRP  
delamination resistance improvement

*Emanuele Maccaferri<sup>a,\*</sup>, Jacopo Ortolani<sup>a,b</sup>, Laura Mazzocchetti<sup>a,b,\*</sup>, Tiziana Benelli<sup>a,b</sup>,*

*Tommaso Maria Brugo<sup>b,c</sup>, Andrea Zucchelli<sup>b,c</sup>, Loris Giordini<sup>a,b</sup>*

<sup>a</sup> *Department of Industrial Chemistry “Toso Montanari”, University of Bologna, Viale Risorgimento 4, 40136 Bologna, Italy.*

<sup>b</sup> *Interdepartmental Center for Industrial Research on Advanced Applications in Mechanical Engineering and Materials Technology, CIRI-MAM, University of Bologna, Viale Risorgimento 2, 40136 Bologna, Italy.*

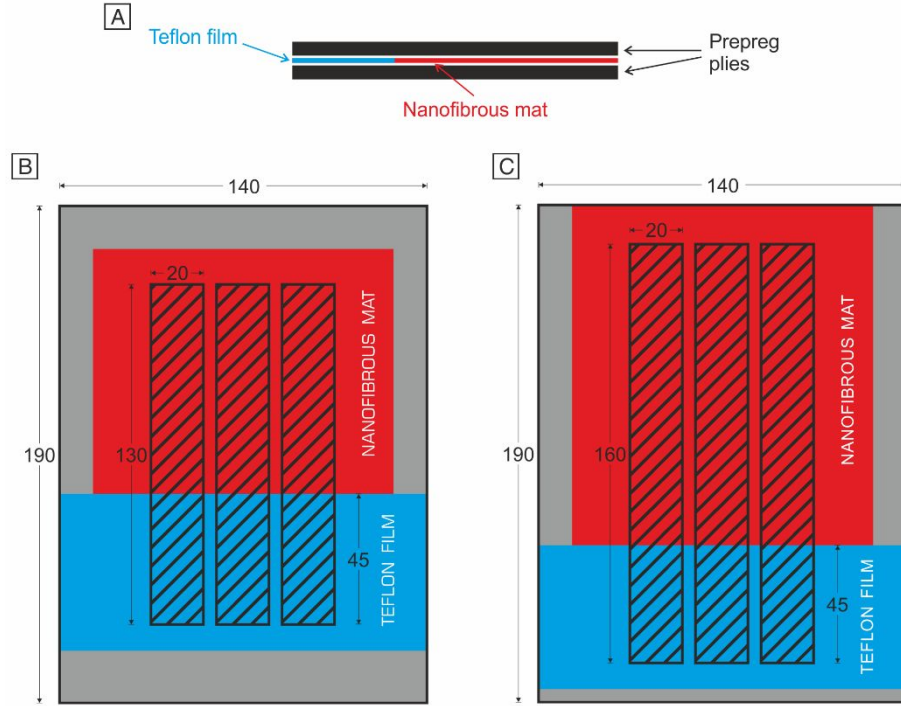
<sup>c</sup> *Department of Industrial Engineering, University of Bologna, Viale Risorgimento 2, 40136 Bologna, Italy.*

\* Corresponding authors: [emanuele.maccaferri3@unibo.it](mailto:emanuele.maccaferri3@unibo.it), [laura.mazzocchetti@unibo.it](mailto:laura.mazzocchetti@unibo.it)

## **S1. Production of CFRP laminates for DCB, ENF, 3PB and DMA tests**

CFRP panels for DCB, ENF, 3PB and DMA tests were produced via hand lay-up in an air-conditioned room (21-23 °C, 25-27% relative humidity). The nanofibrous membranes were directly applied with their paper substrate onto the prepreg during the hand lay-up. Before the addition of the next prepreg ply, the supporting paper was removed. To favour the impregnation of the nanofibrous mat, uncured panels underwent a preliminary treatment of 2 h at 40 °C under vacuum before curing cycle in autoclave. Then, they were cured in an autoclave (2 h at 135 °C, under vacuum, 6 bar external pressure, heating/cooling ramp 2 °C/min).

CFRP panels for DCB and ENF tests (Figure S1), 140 × 190 mm, are constituted by 14 CFRP plies in total. Only the central interface was modified with nanofibrous PEO. A Teflon film was used as a crack trigger. The specimens were obtained by cutting out the panel; edge parts (minimum 15 mm) were discarded for avoiding any inhomogeneity.



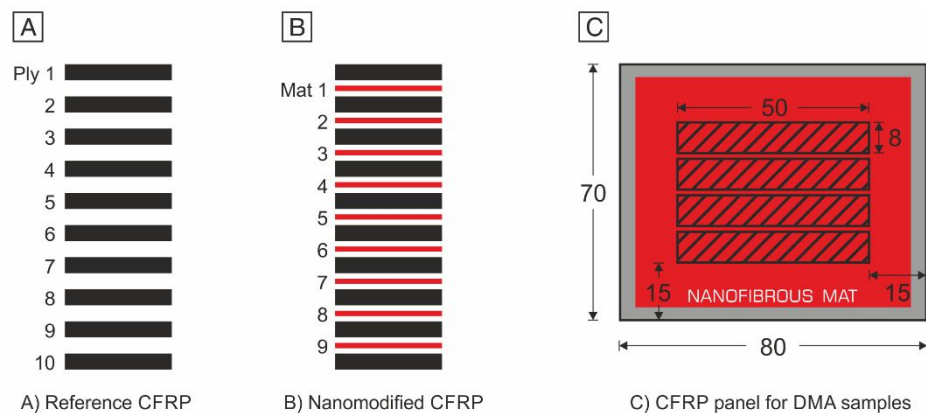
**Figure S1.** CFRP panels for characterization of delamination resistance: laminate section view (A) and dimensions (in mm) of panels and specimens for DCB (B) and ENF (C) tests.

DCB specimens have the following final dimensions: 130 mm total length, 20 mm width ( $b$ ), 45 mm initial crack length ( $a_0$ ). To anchor the specimen on the testing machine, aluminium blocks were fixed to the DCB specimen with epoxy resin glue.

ENF specimens had the following dimensions: 160 mm total length, 20 mm width ( $b$ ), 45 mm initial crack length ( $a_0$ ).

The laminates for the 3PB and DMA tests are constituted by 10 CFRP plies in total. The PEO-modified sample has all the interfaces nanomodified (Figure S2). The specimens for the 3PB test are 110 × 10 mm, obtained by cutting out 150 × 70 mm CFRP panels; the ones for DMA are 50 × 8 mm, obtained by

cutting out  $80 \times 70$  mm CFRP panels. In both cases, edge parts of the panel ( $\approx 15$  mm) were discarded to ensure specimen homogeneity.



**Figure S2.** Stacking sequence of plies/mats for production of 3PB and DMA laminates: (A) unmodified and (B) nanomodified CFRP laminates. (C) Dimensions (in mm) of CFRP panels and specimens for DMA.