HIGH IMPACT STRENGTH COMPOSITES BASED ON IMPACT-MODIFIED ACRYLIC AND BACTERIAL CELLULOSE

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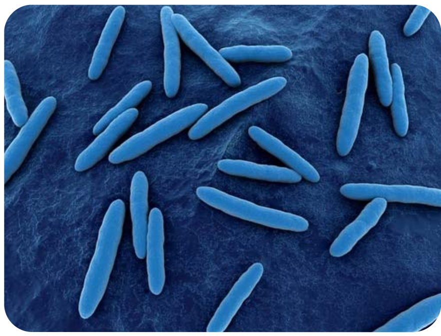
TAPPI Nano 2021 Virtual Conference
15-16 June 2021

OUTLINE

- What is Bacterial cellulose (BC)?
- Motivation of this study
- Materials & methods
- Properties (PEG-sized) BC nanopapers
- Properties (PEG-sized) BC-reinforced laminated acrylic composites
- Conclusions

WHAT IS BACTERIAL CELLULOSE (BC)?



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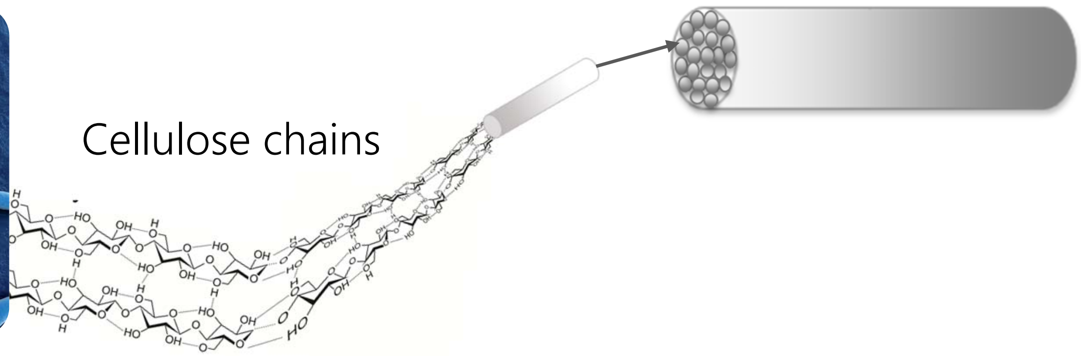
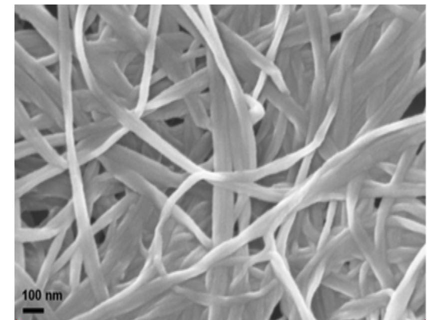
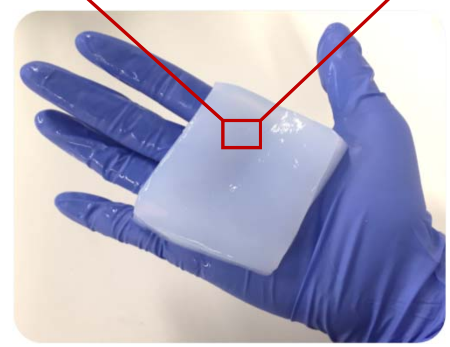






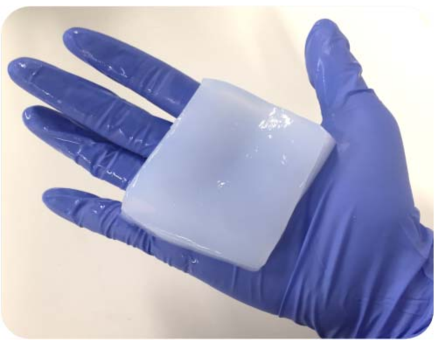
Bacterial cellulose (BC)

- Jelly like 3D fibres network
- Comercially available
- Chemically pure
- X_c= ~90%
- BC single fibre, E =114 Gpa

(Hsieh YC et al., Cellulose, 2008) (Lee KY et al., Cellulose, 2011)

BACTERIAL CELLULOSE WET AND DRY

Bacterial cellulose (BC)



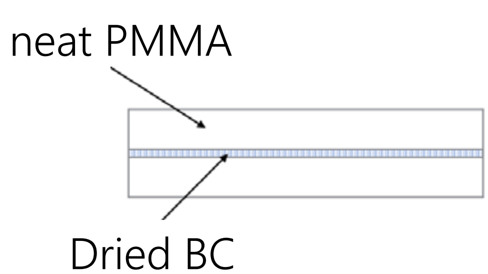
HORNIFICATION
Irreversible hydrogen bond formation between adjacent fibres

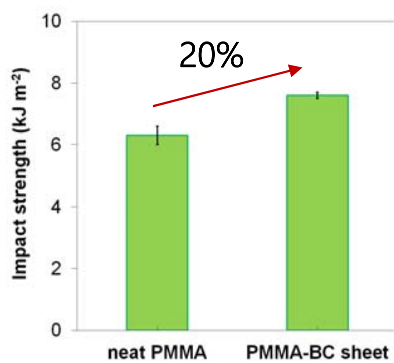
Dryin

~~Re ation~~

Pellicle, 99 wt.-% water
Three-dimensional network

Dried BC (BC nanopaper)
Two-dimensional network





(Santmarti A et al., ACS Omega, 2019)

E = 20 GPa

σ = 188 MPa

ε = 1.4%

1. COULD WE CIRCUMVENT INTERFIBRIL HORNIFICATION TO ENHANCED THE TOUGHNESS OF BC NANOPAPER?

2. COULD THE TOUGHENED BC NANOPAPER BE TRANSLATED TO IMPROVED IMPACT STRENGTH OF BC COMPOSITES?

MATERIALS

- Matrix:

  Commercially impact-modified acrylic (IM-acrylic)

- Reinforcement:

  Bacterial cellulose (BC) nanopapers

- Chemicals:

  ✓ Poly(ethylene glycol) (PEG), *Mw: 200, 400, 600 g mol*$^{-1}$

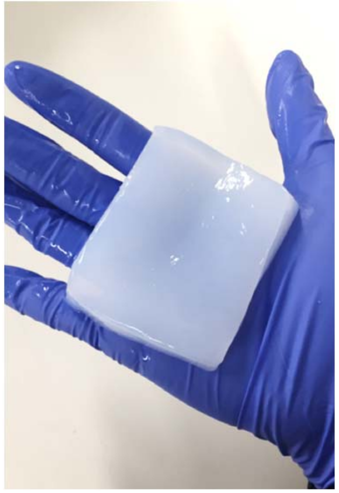
  ✓ Triethyl citrate (TEC) plasticiser

  ✓ MMA monomer

  ✓ AIBN initiator (2,2′-azobis (2- methylpropionitrile))

  TEC-Plasticised PMMA ➡ Interlayer adhesive

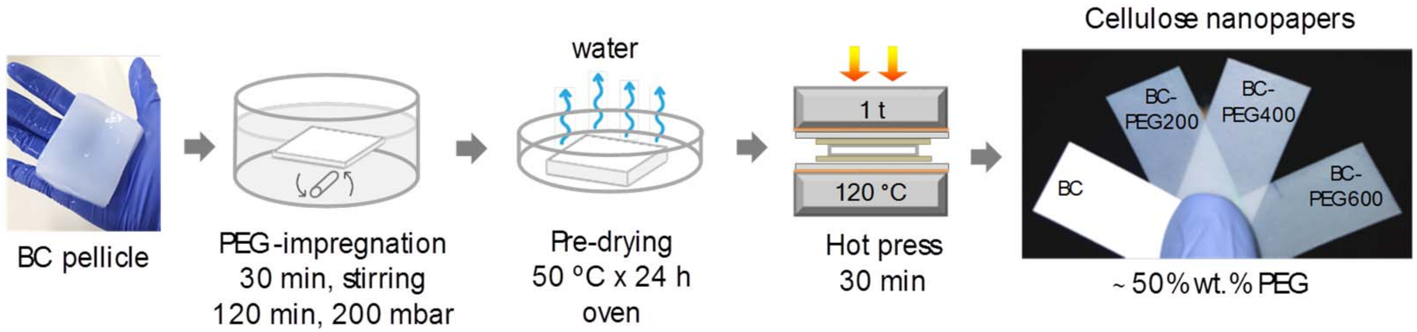
IM-acrylic



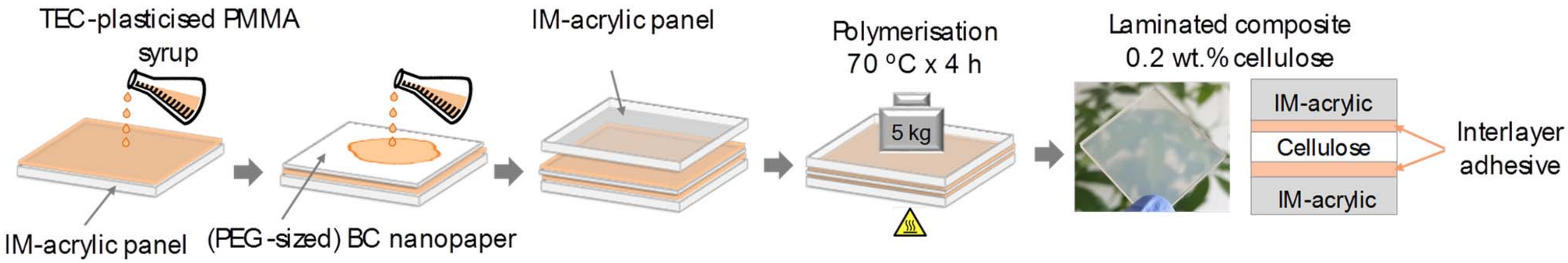
Bacterial cellulose

METHODS

1) Sizing BC with PEG to produce PEG-sized BC nanopapers

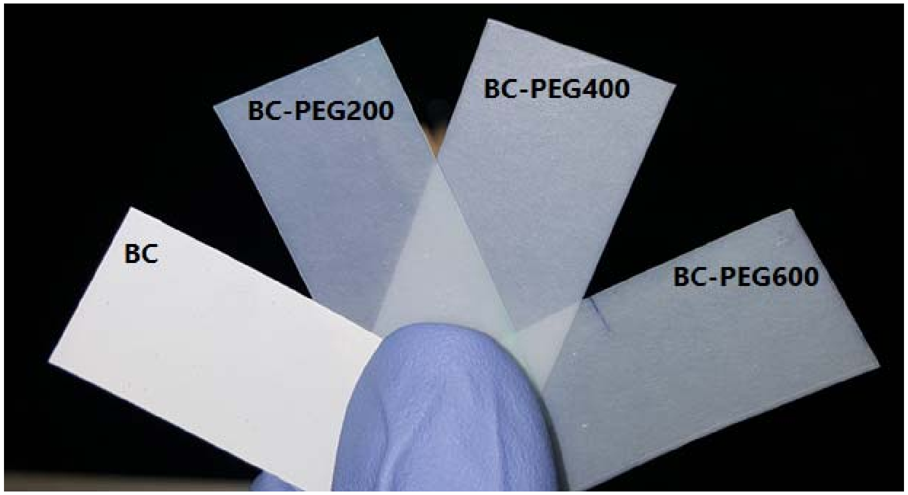


2) Preparation laminated acrylic composites reinforced with (PEG-sized) BC nanopapers

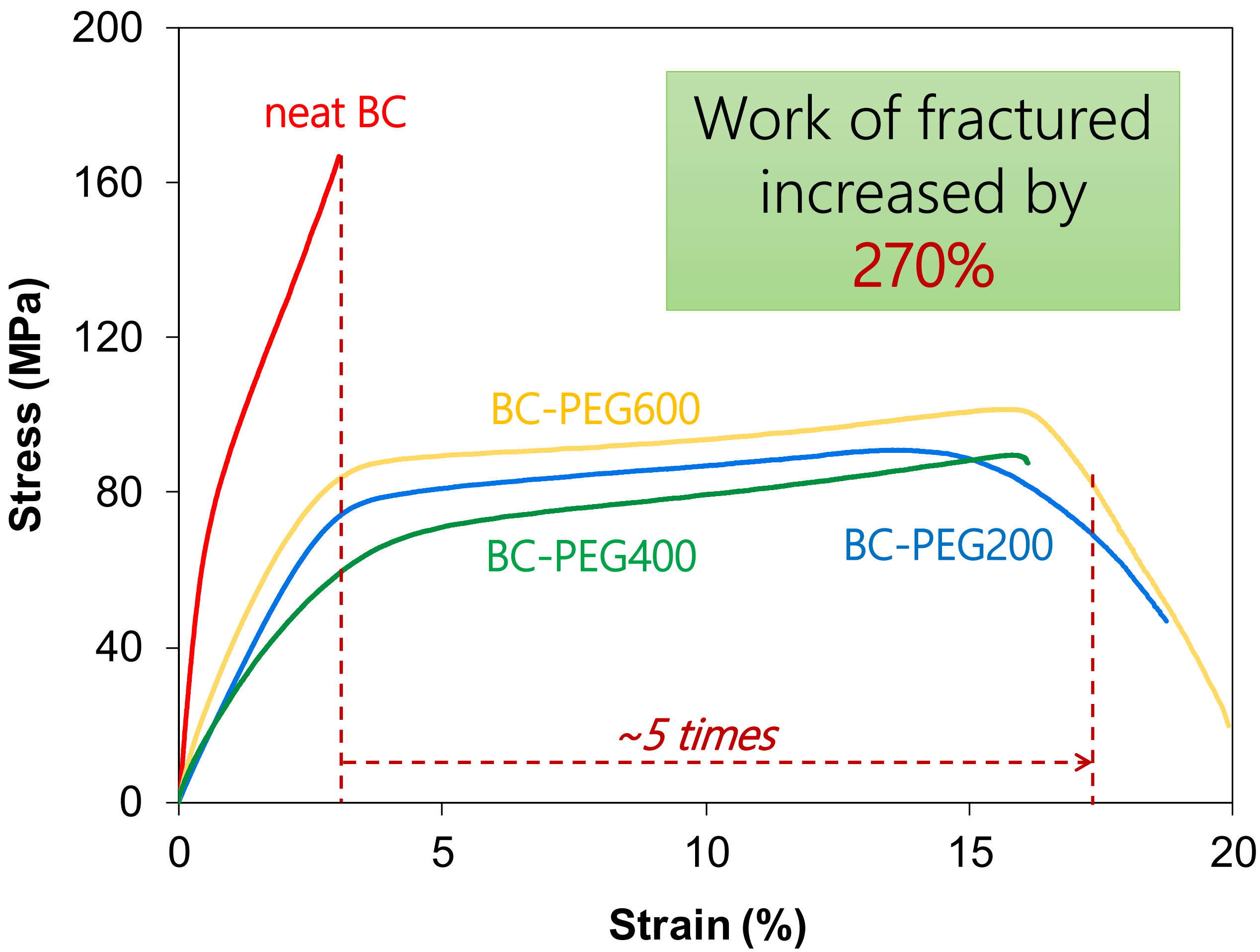


PROPERTIES

BC AND PEG-SIZED BC NANOPAPERS

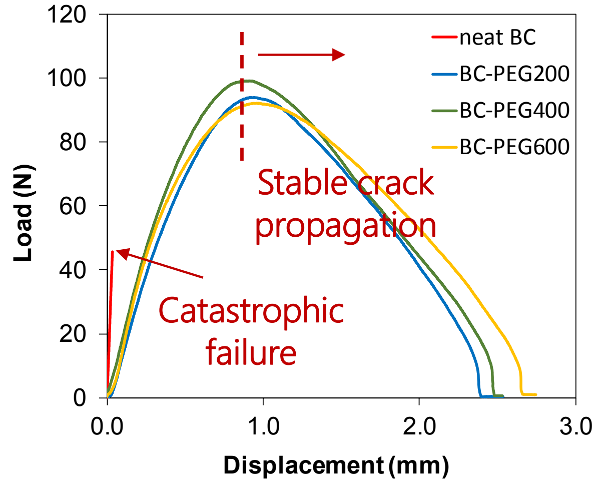


TENSILE PROPERTIES (PEG-SIZED) BC NANOPAPERS

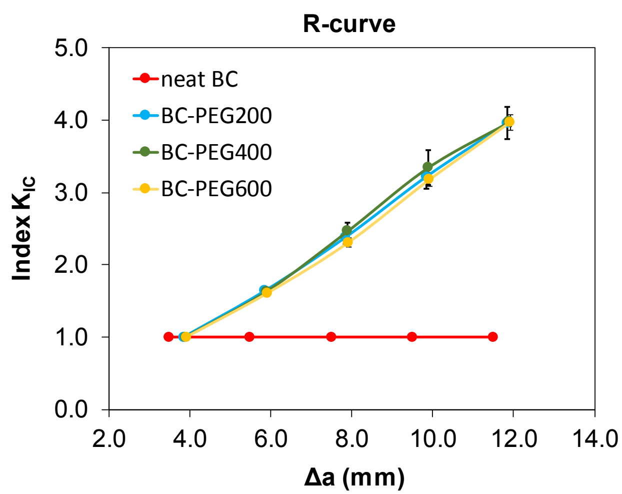


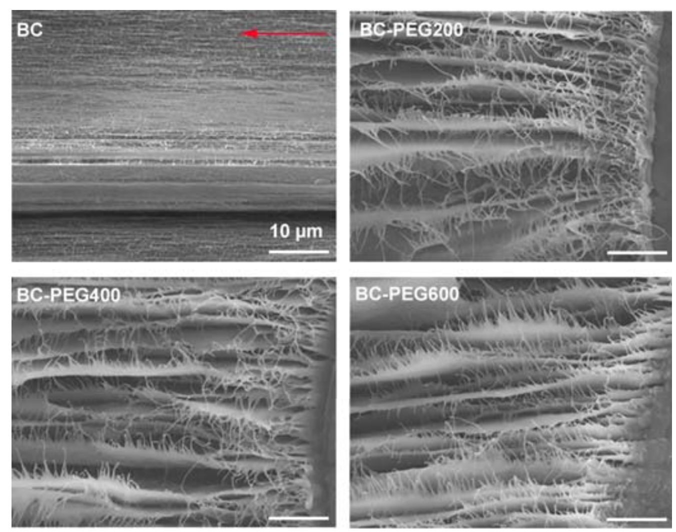
Nanopapers	Work of fracture ($MJ\ m^{-3}$)
BC	3.8 ± 0.6
BC-PEG200	11.9 ± 3.4
BC-PEG400	12.2 ± 1.2
BC-PEG600	14.1 ± 3.4

FRACTURE TOUGHNESS (PEG-SIZED) BC NANOPAPERS

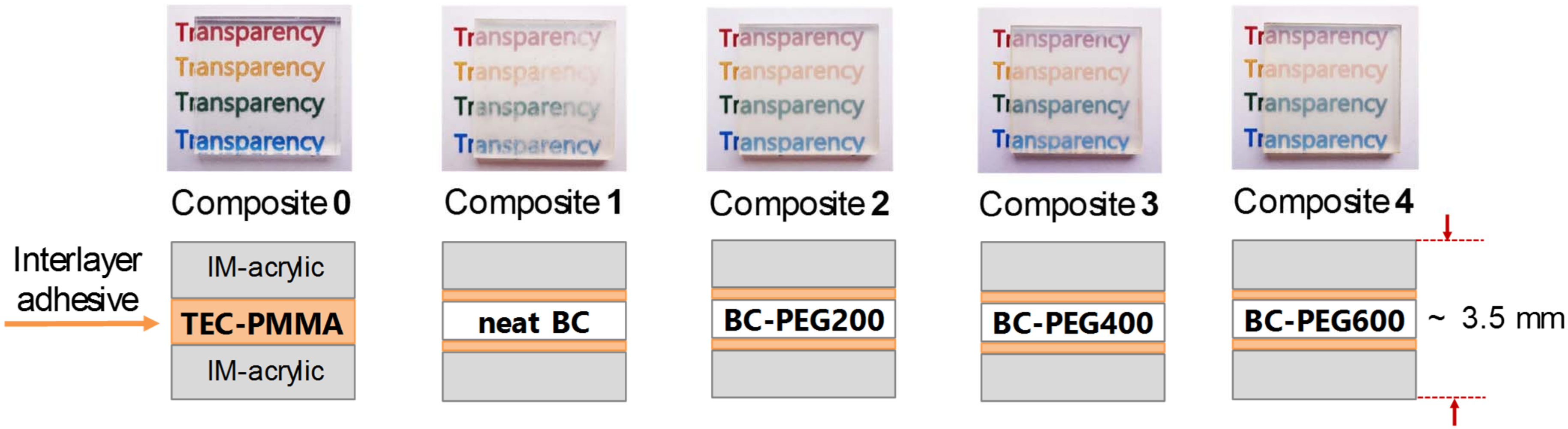


Nanopapers	$\widetilde{K}_{IC}$ (MPa $m^{0.5}$)
neat BC	10.6 ± 1.8
BC-PEG200	8.4 ± 0.7
BC-PEG400	7.8 ± 0.7
BC-PEG600	6.6 ± 0.8

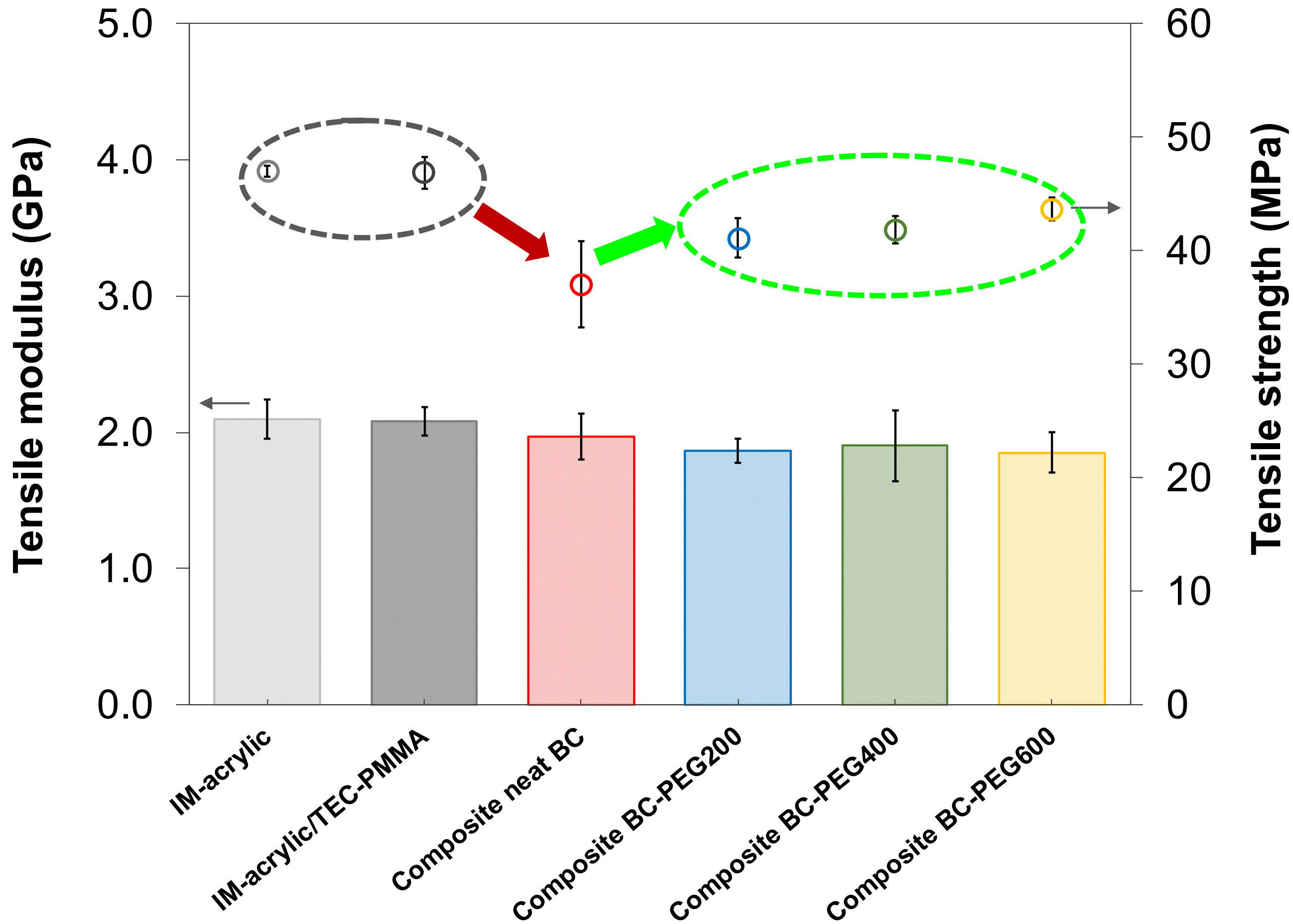




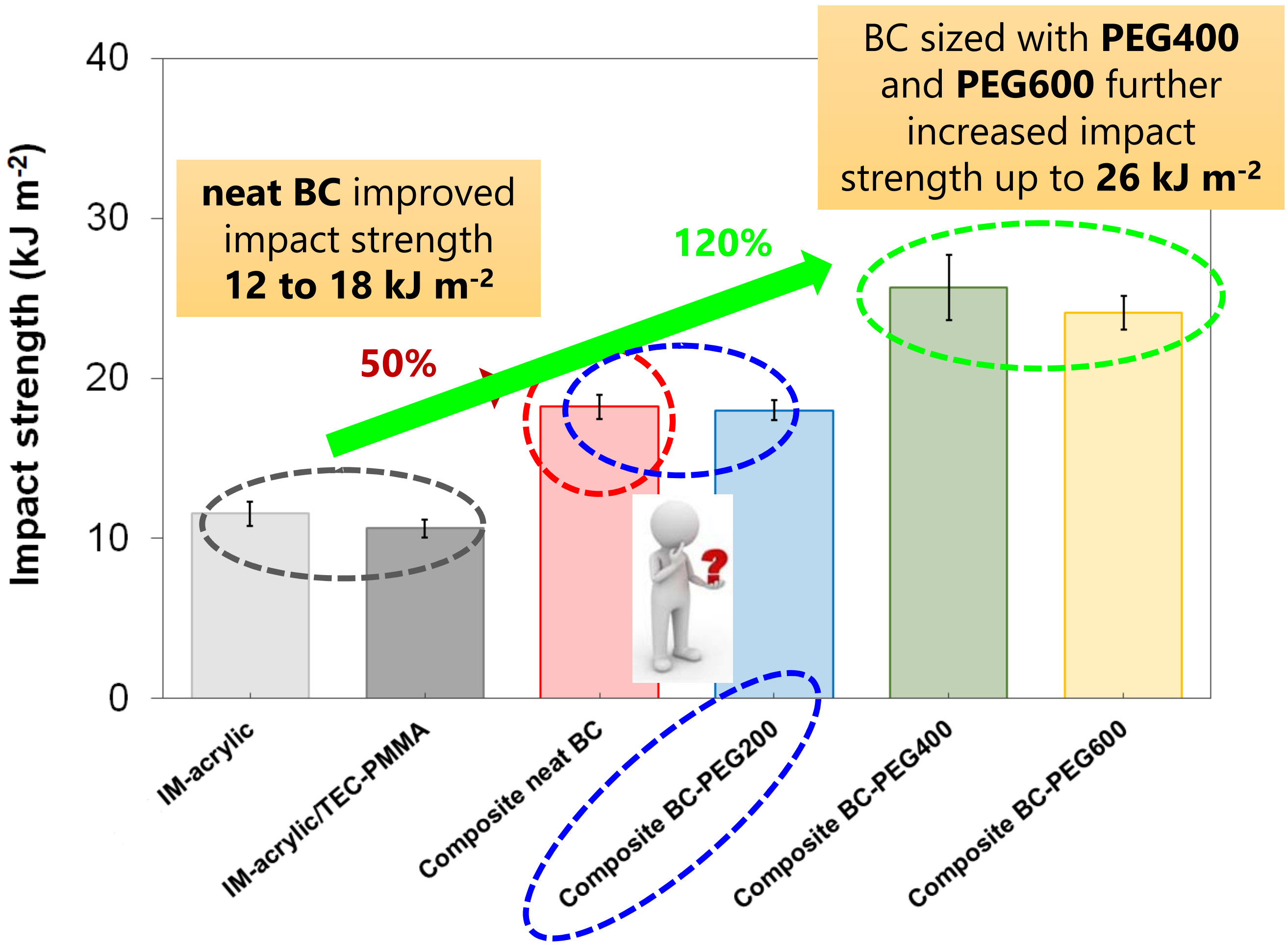
PROPERTIES
(PEG-SIZED) BC-REINFORCED LAMINATED ACRYLIC COMPOSITES

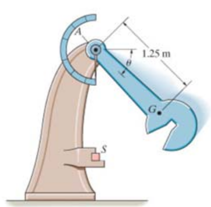


TENSILE PROPERTIES LAMINATED ACRYLIC COMPOSITES

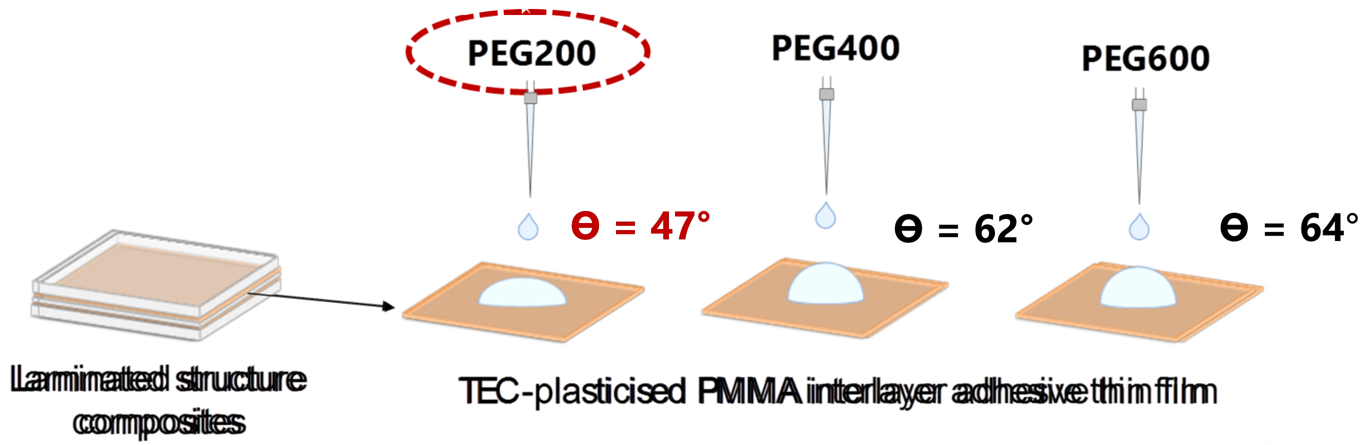


CHARPY IMPACT STRENGTH LAMINATED ACRYLIC COMPOSITES



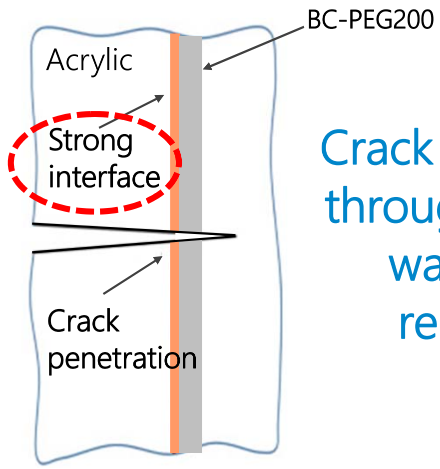


CONTACT ANGLE MEASUREMENTS

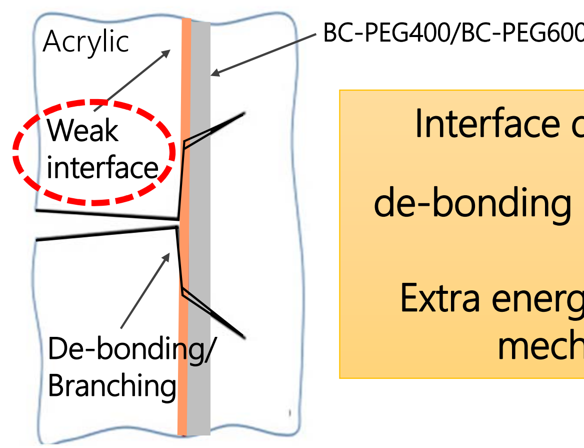


Lower contact angle ➡ Larger interactions at interface ➡ Stronger interface

De-bonding BC nanopaper



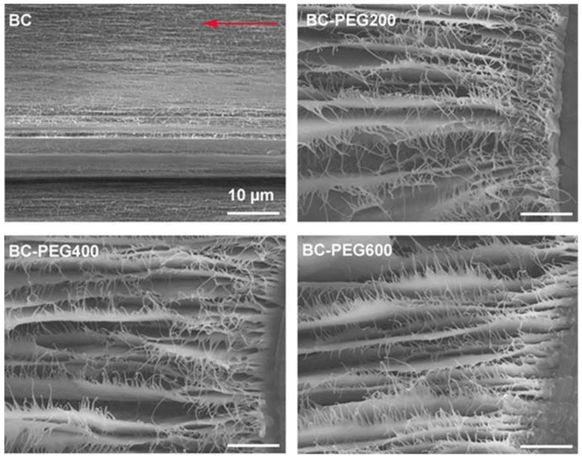
Crack propagates through the path way of less resistance

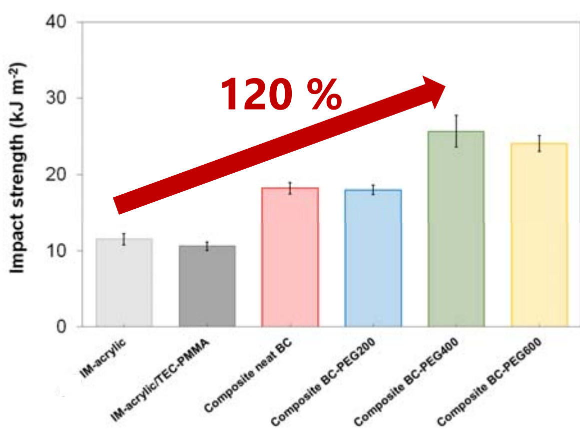


Interface de-bonding
+
de-bonding BC nanopaper

Extra energy absorbing mechanism

CONCLUSIONS





Sizing of never dried BC pellicle with PEG improved the BC nanopaper toughness by **270%**

Low load fraction of bacterial cellulose (0.2 wt.%) increased significantly the impact strength of commercial impact-modified acrylic by **120%**

Simple method: making BC paper, sizing BC paper & lamination of composite

THANKS FOR YOUR ATTENTION!

UK Engineering and Physical Sciences Research Council(EP/N026489/1)

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