Cellulose Nanofiber Reinforced Thermoplastic Resins for Lightweight Parts

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TAPPI

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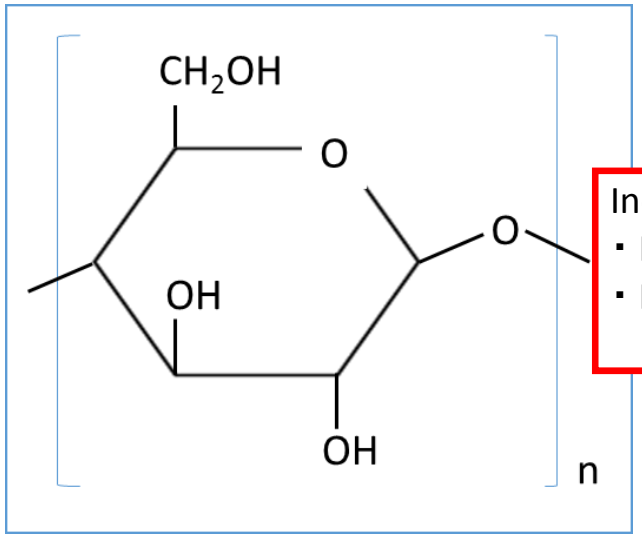
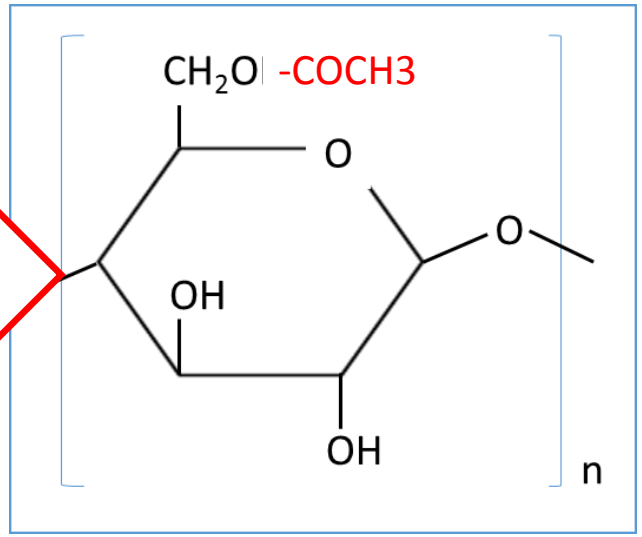
Chemical modified cellulose from KYOTO PROCESS®

Cellulose



Inconvenience of OH group for plastic composite
- Hydrogen bond ⇒ Agglomeration
- Hydrophilicity ⇒ Incompatibility for polymer, Water absorption

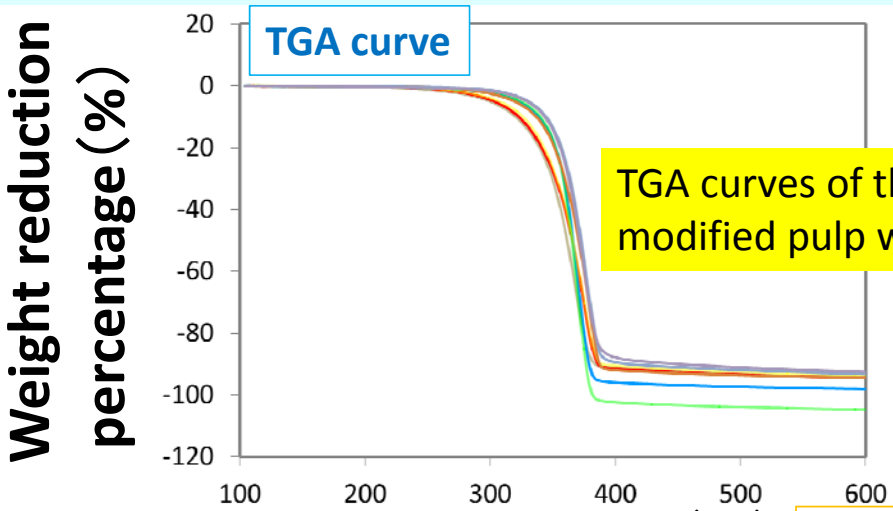
Cellulose acetate



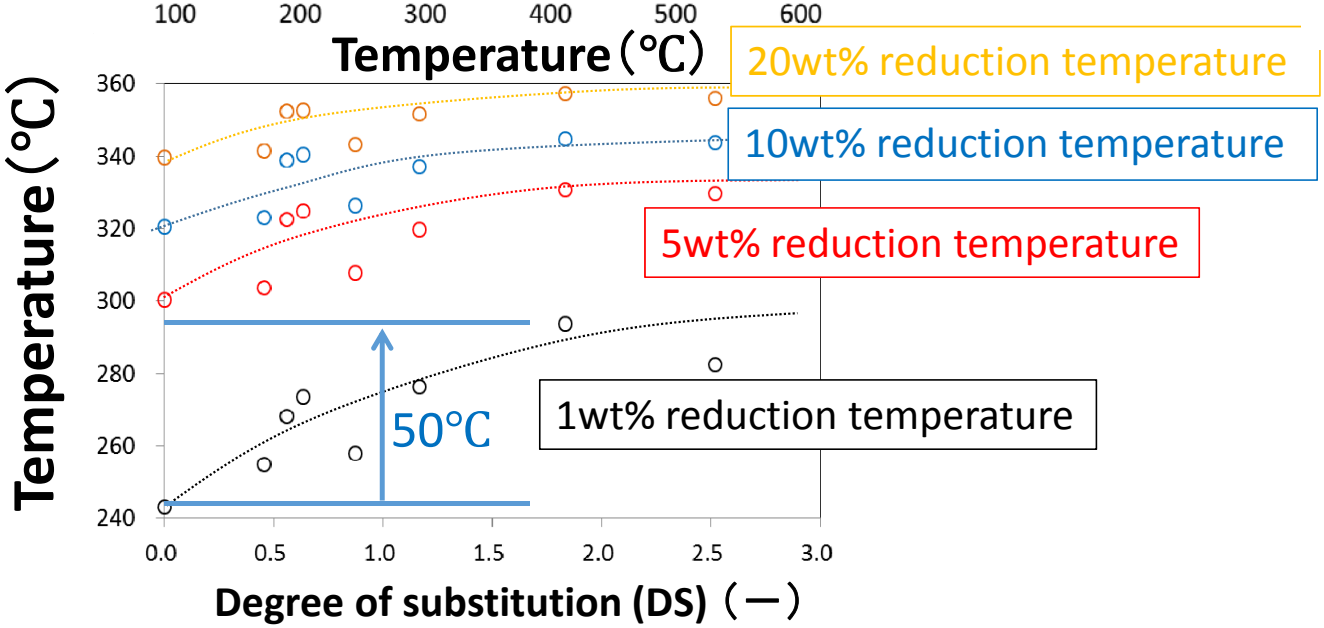
Why Cellulose acetate？
- Giving a hydrophobic
- Giving a heatproof
- Low cost
- Already practical use, therefore safe
- Easy to control modification degree etc.

The 1st candidate of the modified cellulose for the plastic reinforcement.

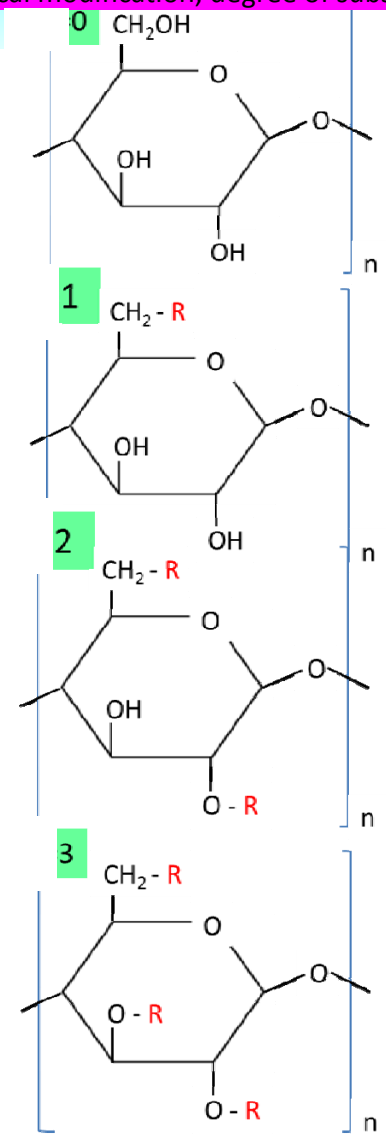
Thermogravimetric analysis (TGA) of chemical modified pulp



TGA curves of the chemical modified pulp with various DS.

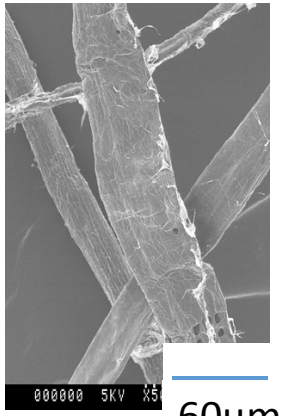


Chemical modification, degree of substitution (DS)



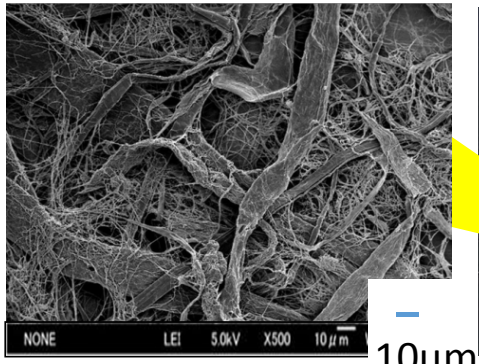
Fabrication Method of CNF/thermoplastic composite in Kyoto Process

Paper pulp



Chemical modification

Chemical pulp, easy fibrillation



Good points
- Easy to filtration and dry
- Easy handling like wood powder

Feed

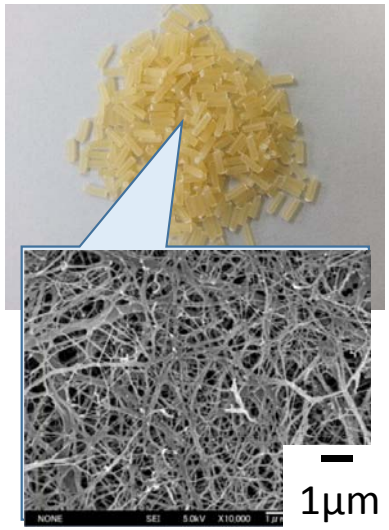
Thermoplastic polymer

Feed

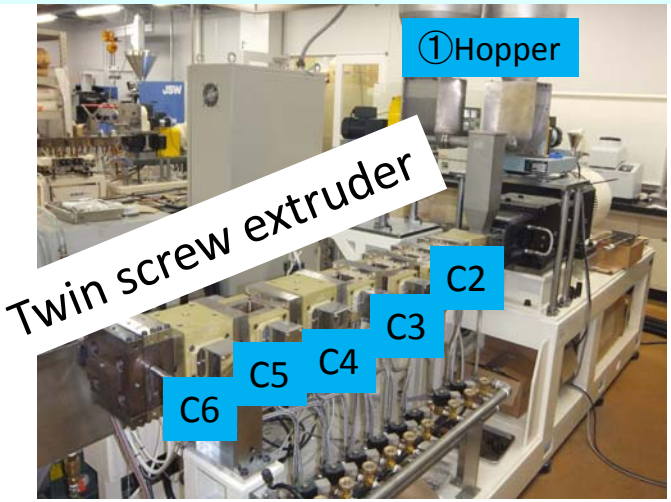
Compounding machine

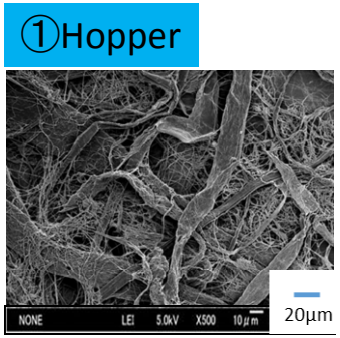
Melting compounding

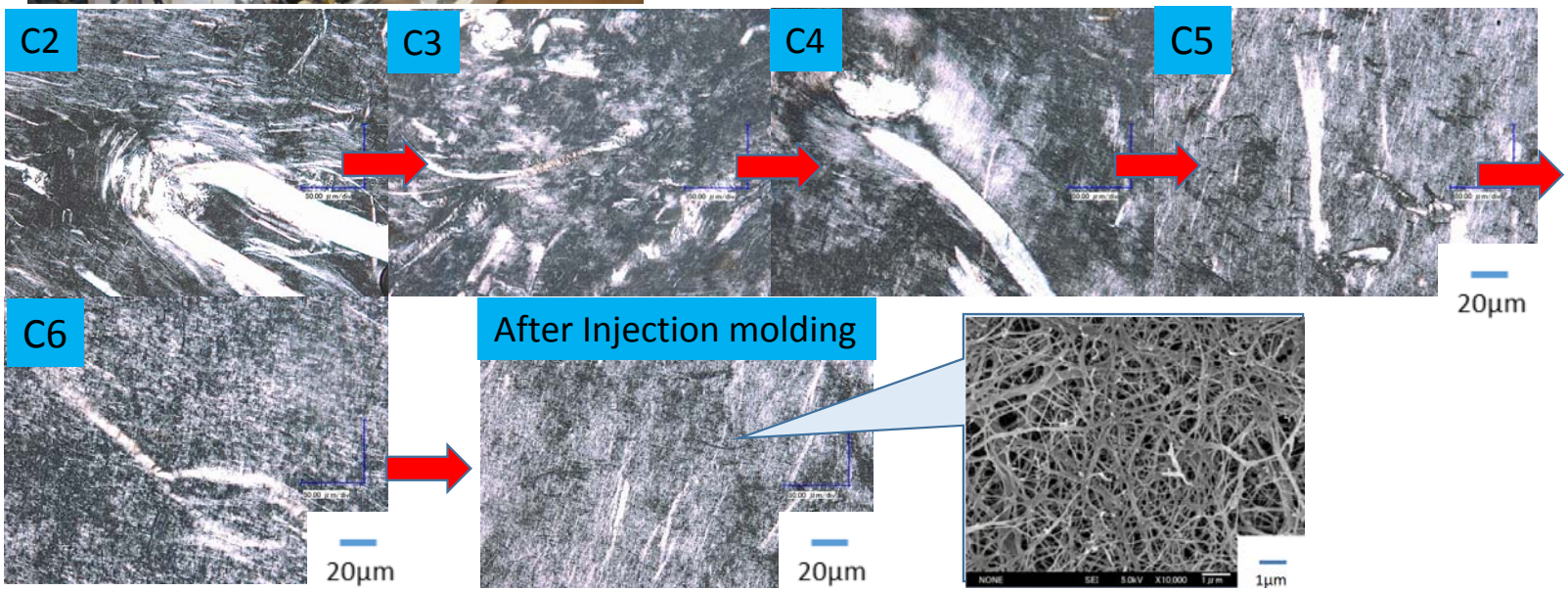
CNF/polymer pellets



Fibrillation of pulp while compounding process (PA6 matrix)

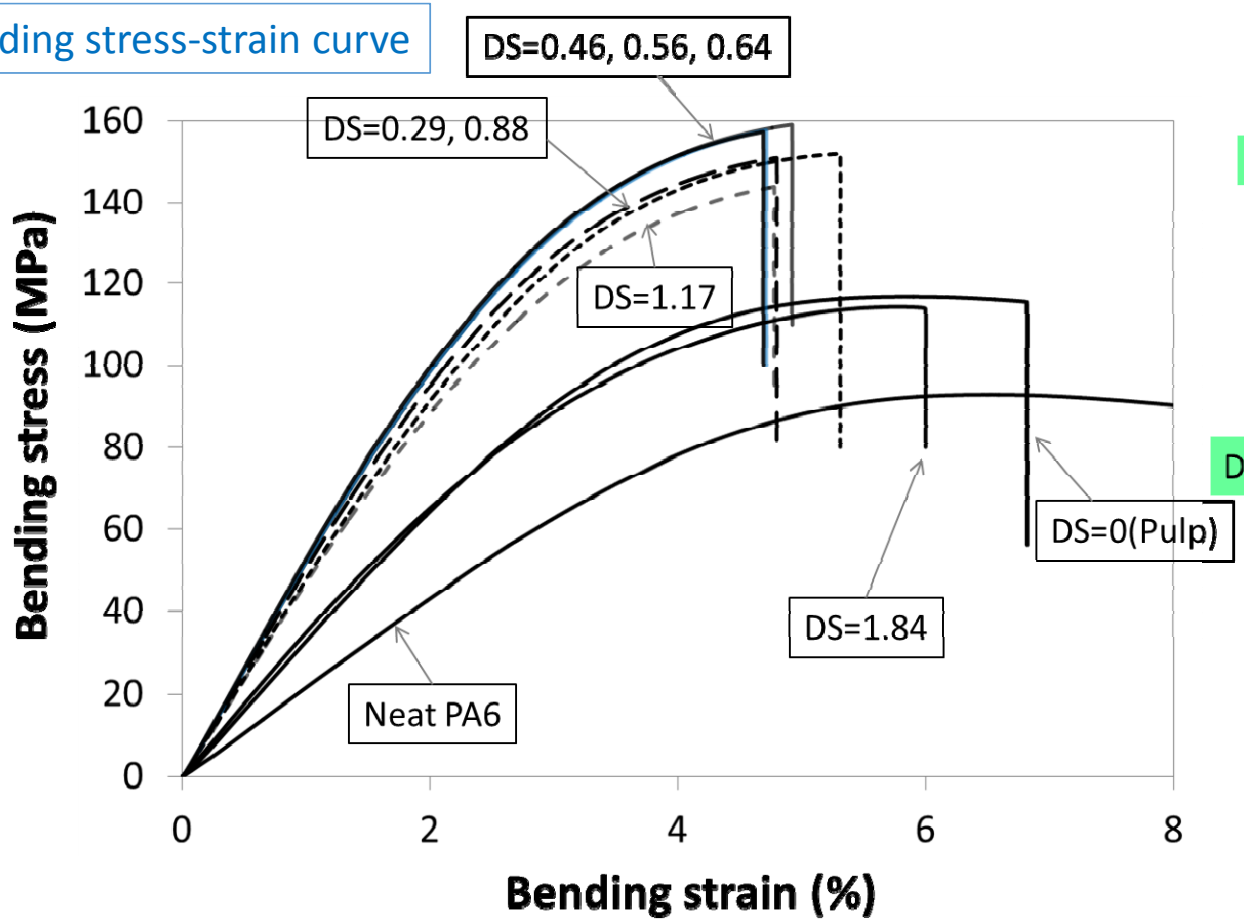


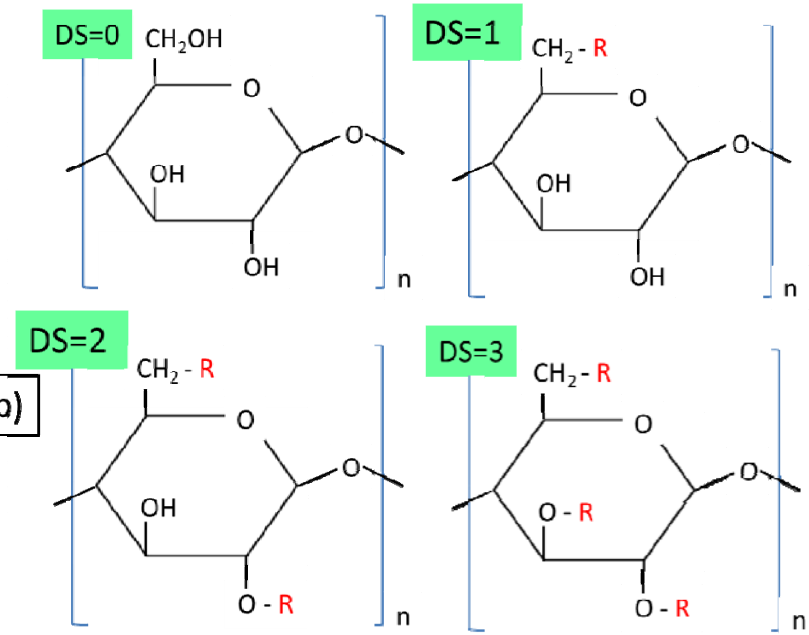




Mechanical properties of CNF-10wt%/PA6 composites（Bending test）

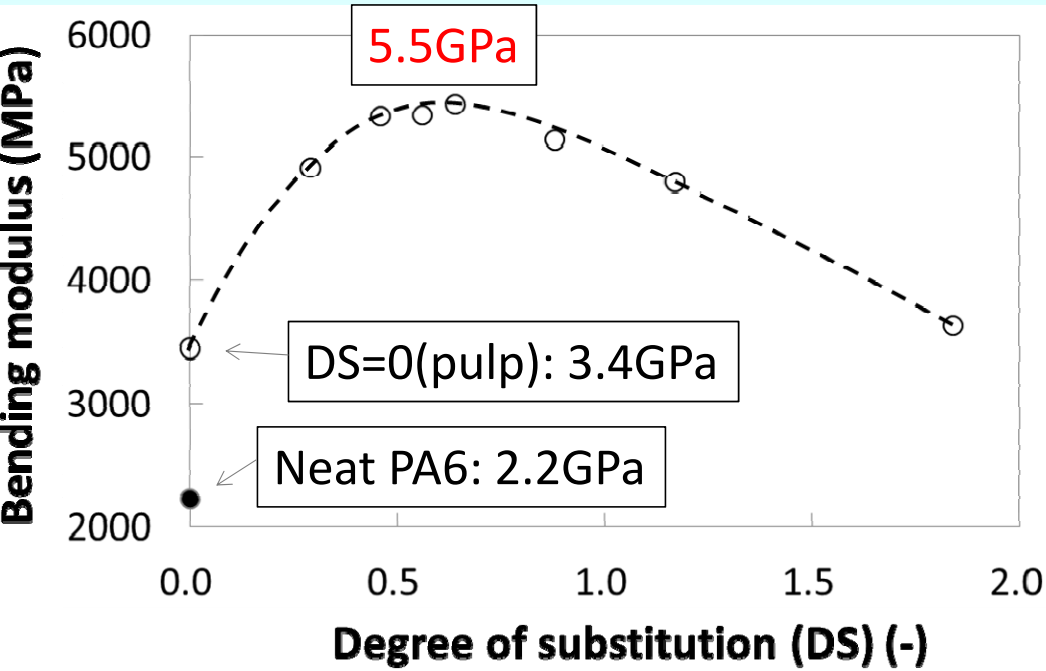
Bending stress-strain curve

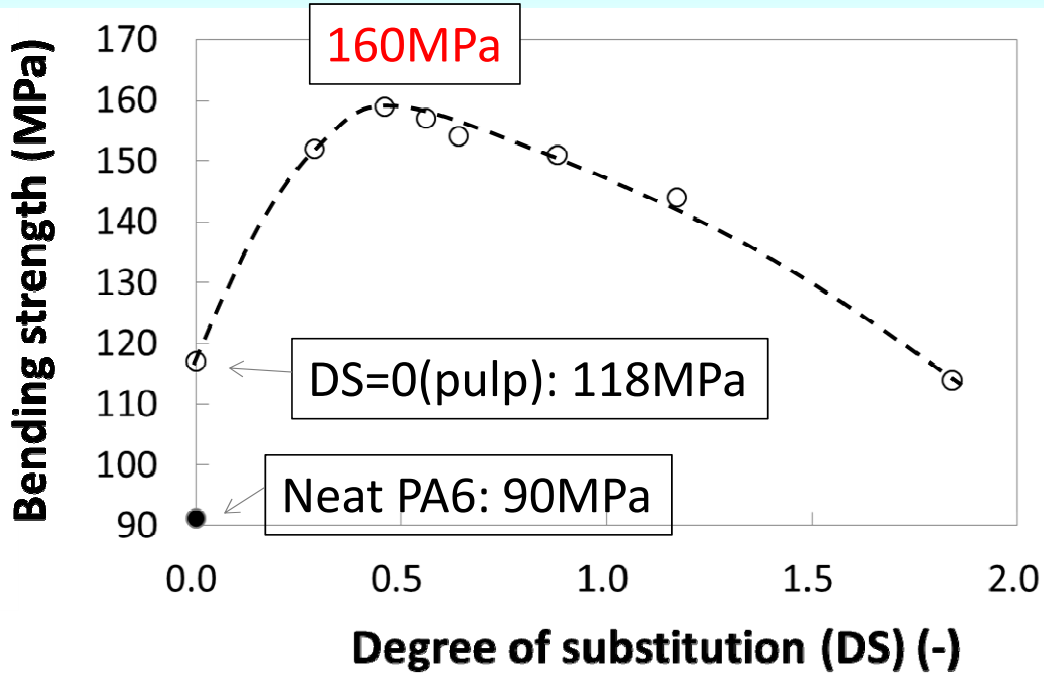




Chemical modification of pulp strongly effects bending modulus.

Mechanical properties of CNF-10wt%/PA6 composites（Bending test summary）

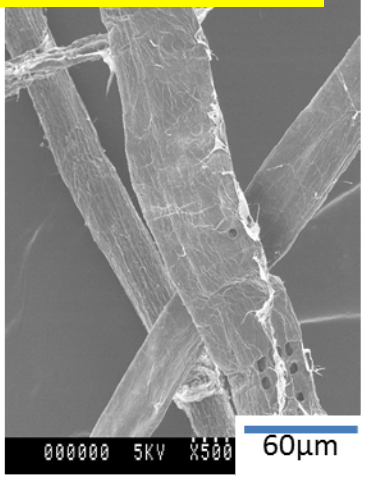




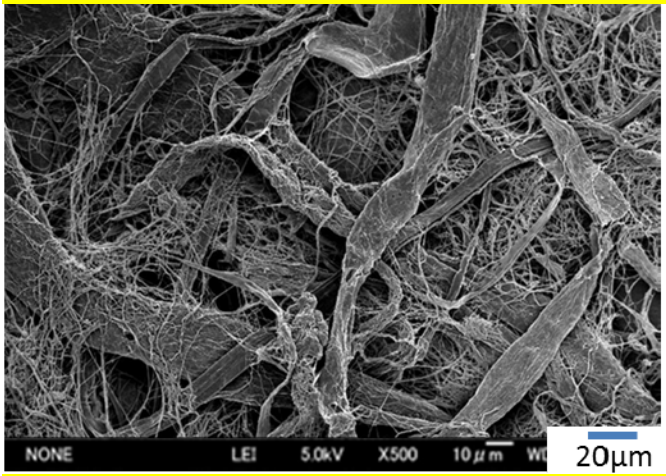
- Bending modulus
  PA6: 2.2GPa⇒pulp: 3.5GPa ⇒modified pulp: 5.5GPa
- Bending strength
  PA6: 90MPa⇒pulp: 118MPa ⇒ DS0.5: 160MPa
- Optimum DS value exist at 0.5.

SEM photo of Cellulose fiber in PA6 matrix after extraction with solvent

（1）Original pulp



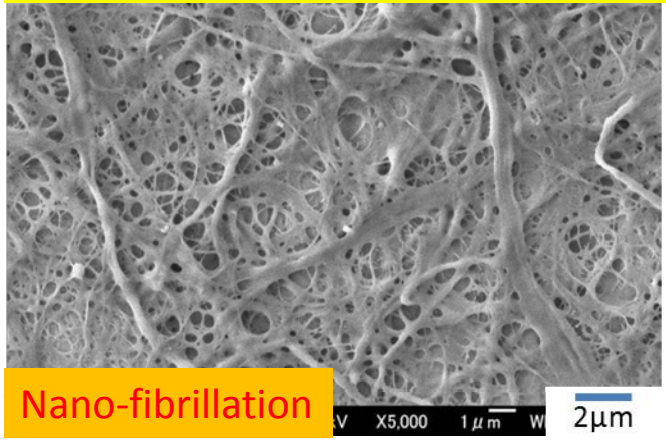
（2）Chmical modified pulp (DS=1.08)



（3）Cellulose fiber extracted from pulp(DS0)/PA6

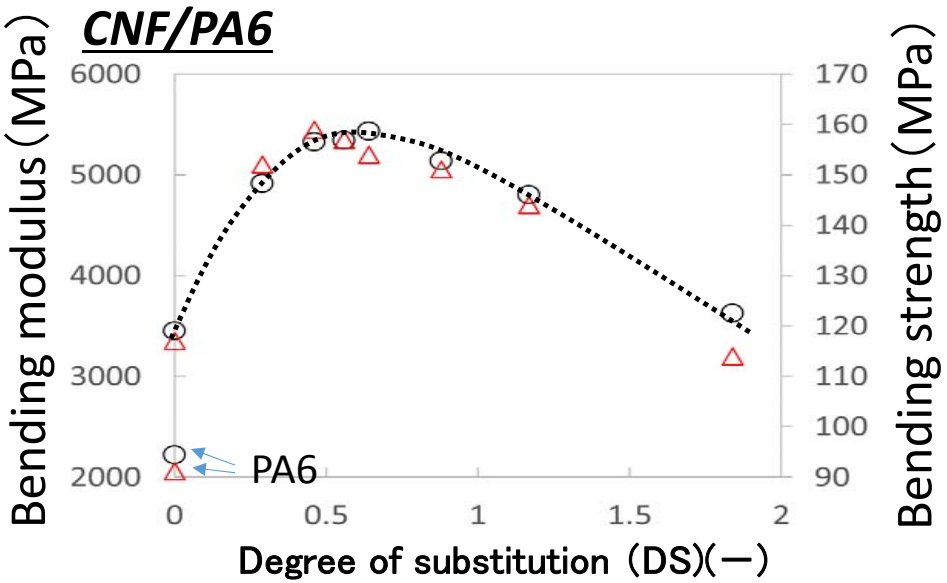
Many agglomerated fibers

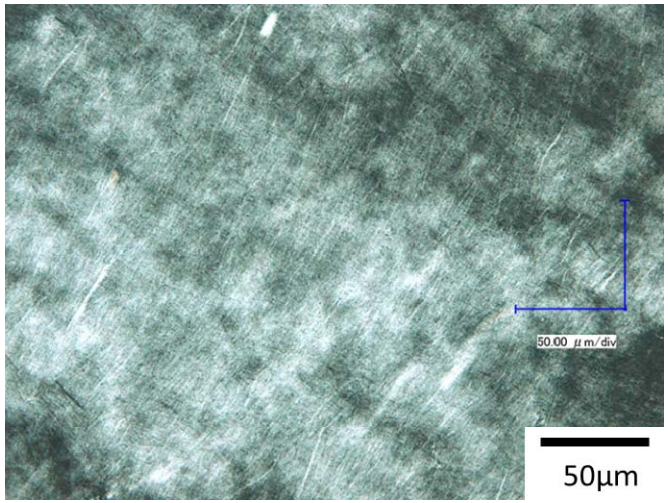
（4）Cellulose fiber
extracted from Ac-NBKP(DS0.46)/PA6 composites

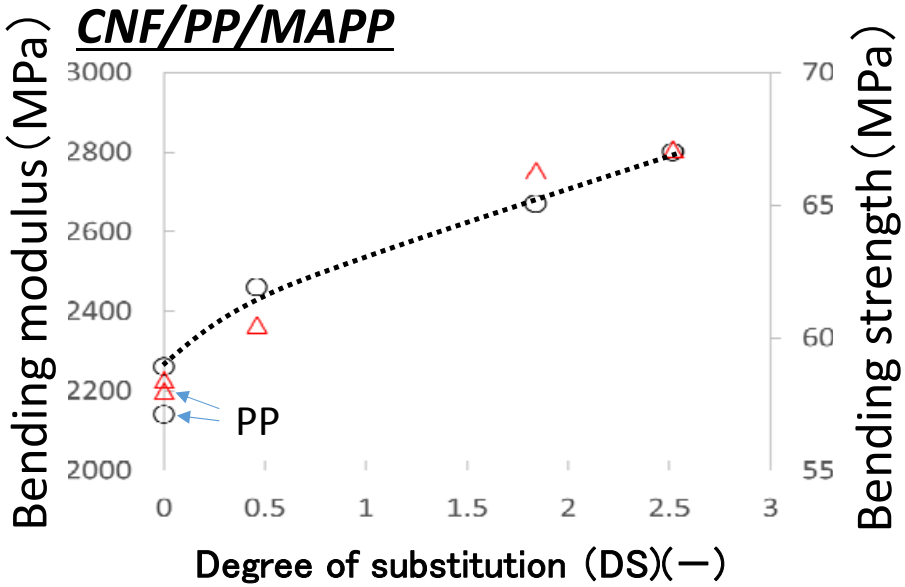


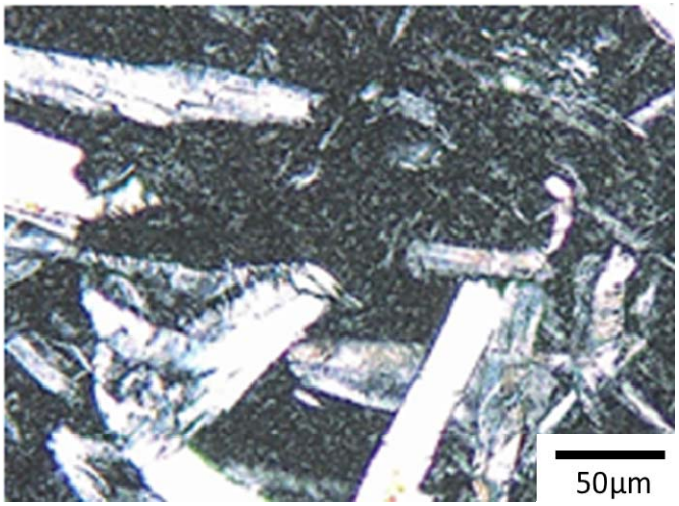
Nano-fibrillation

Comparison with properties of CNF-10wt%/PA6 and polypropylene(PP) composite



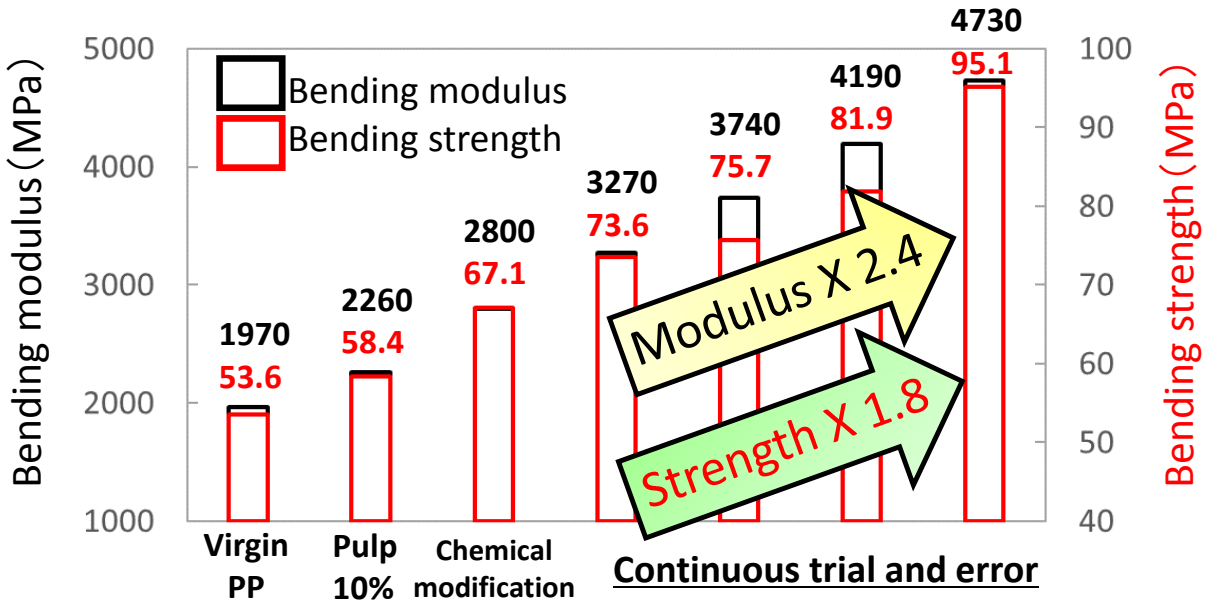




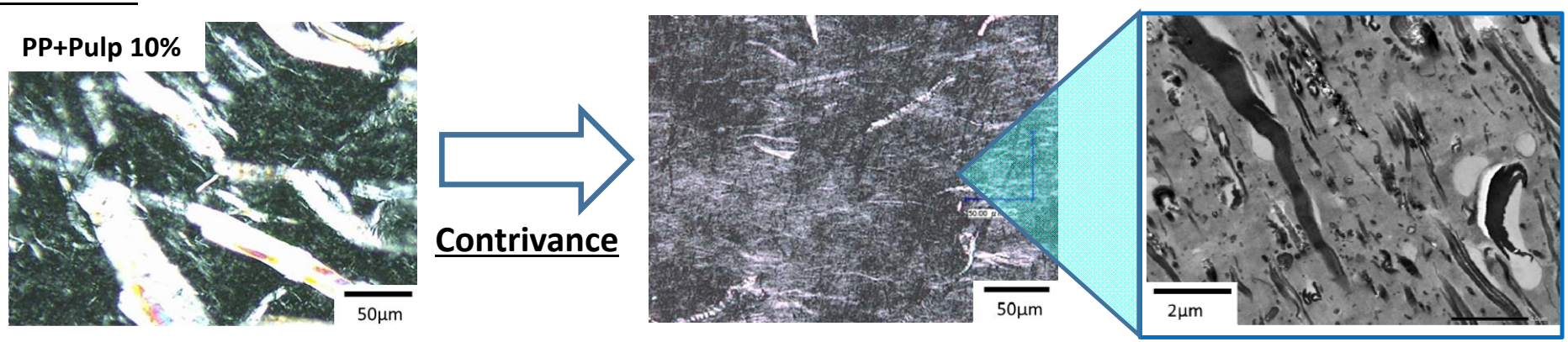


Improvements of CNF-10wt%/PP composite

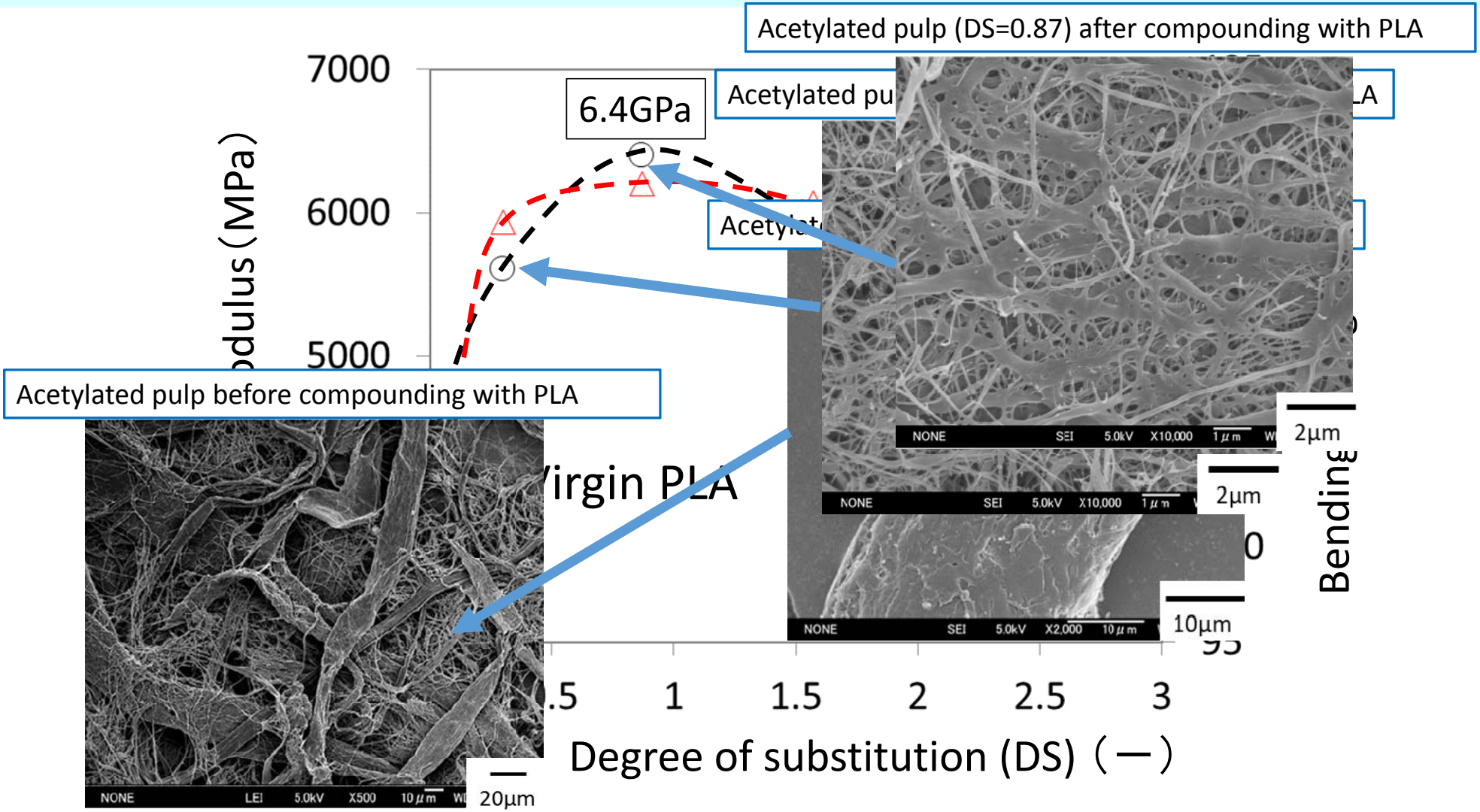
Improvements of Mechanical properties



Improvements of Dispersion state

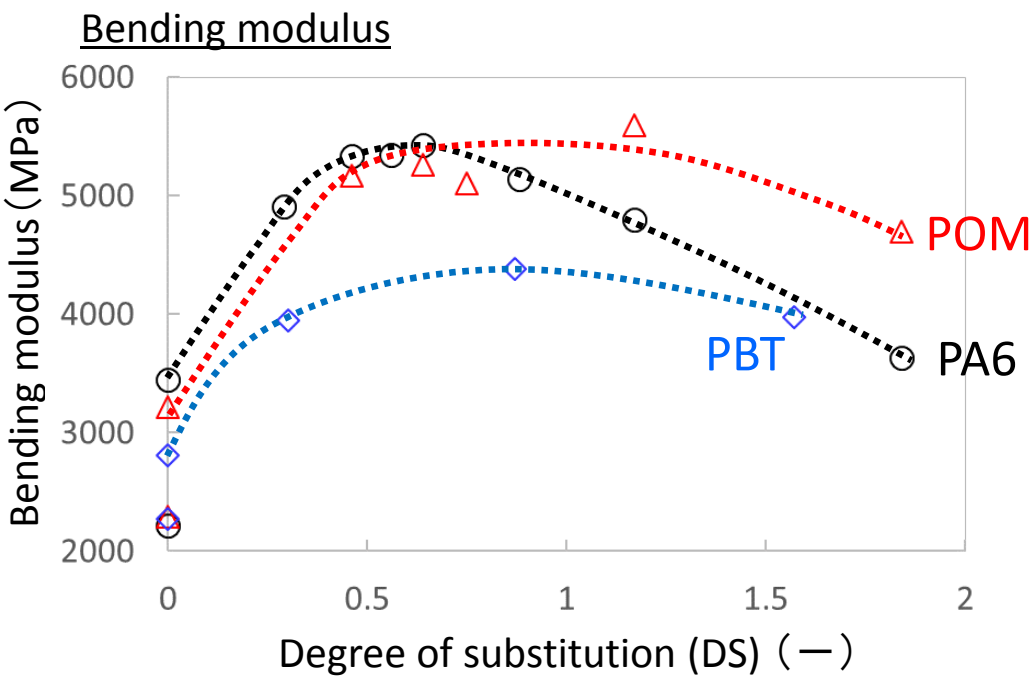


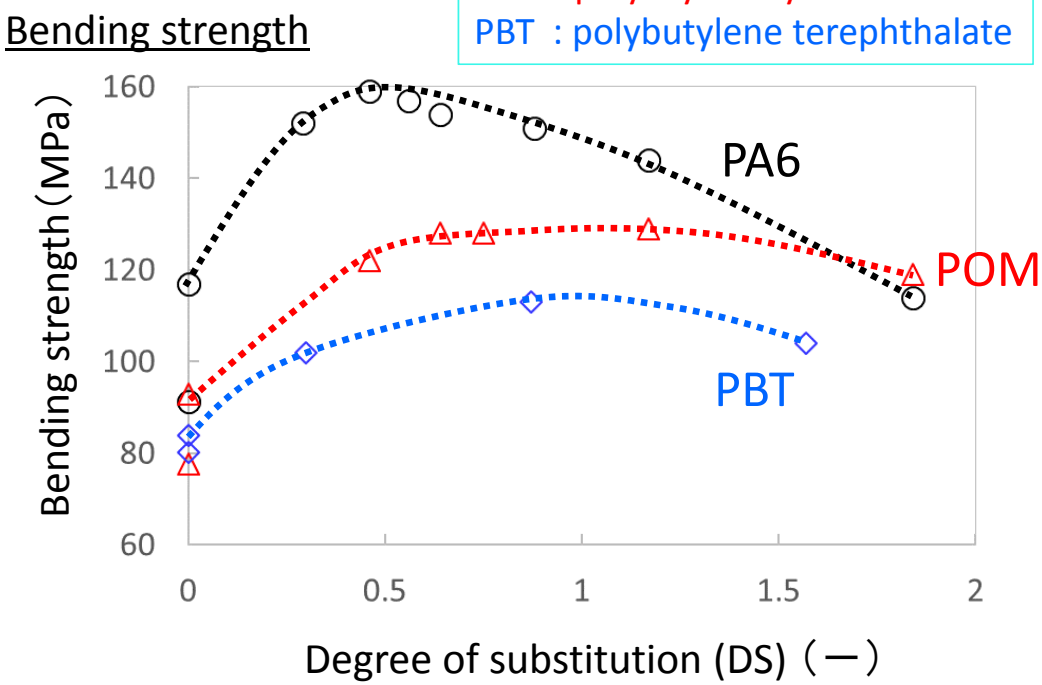
All Bio composites consisted of CNF/PLA



Mechanical properties of engineering plastics composites including CNF-10wt%

PA6 : polyamide6
POM: polyoxymethylene
PBT : polybutylene terephthalate





The best DS is different depending on plastics,

PA6 : DS=0.5～0.7

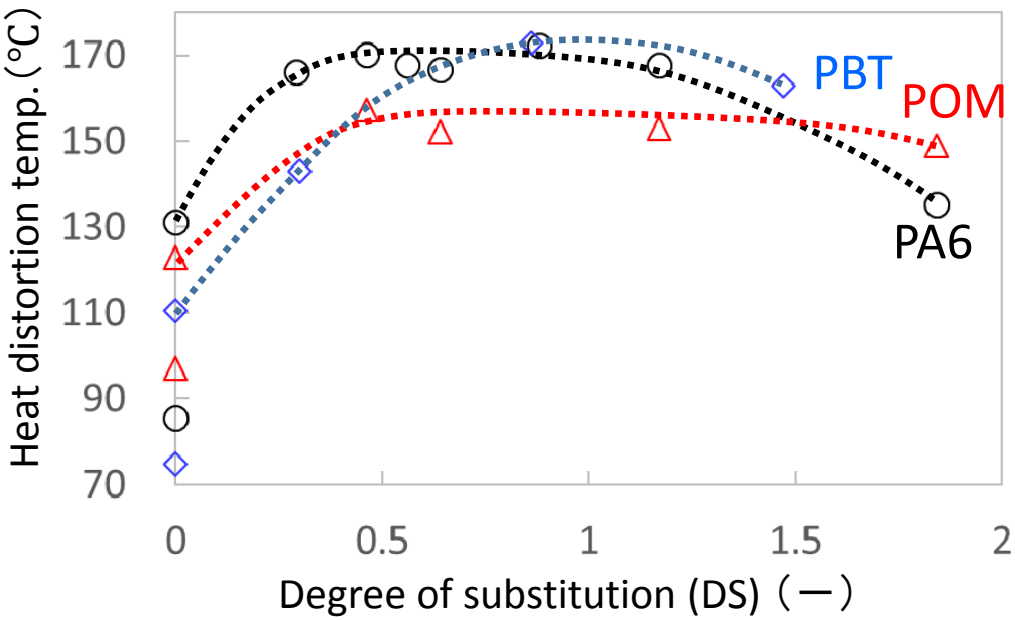
POM: DS=0.5～1.2

PBT : DS=0.5～1.5

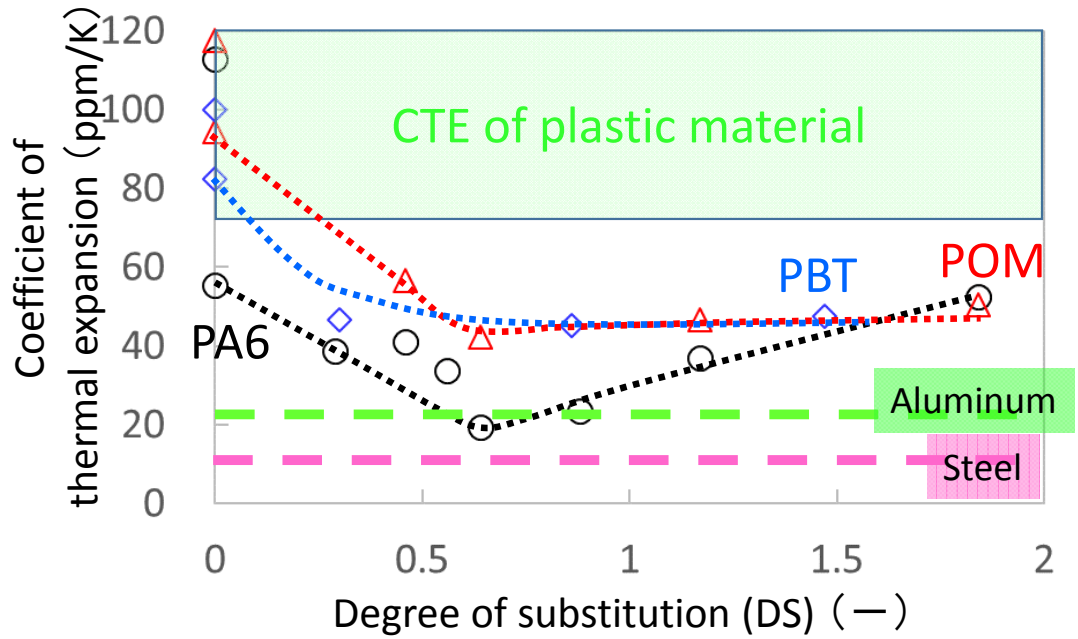
Heat tolerance of engineering plastics composites including CNF-10wt%

PA6 : polyamide6
POM: polyoxymethylene
PBT : polybutylene terephthalate

Heat distortion temperature(HDT)
Loading stress 1.8MPa

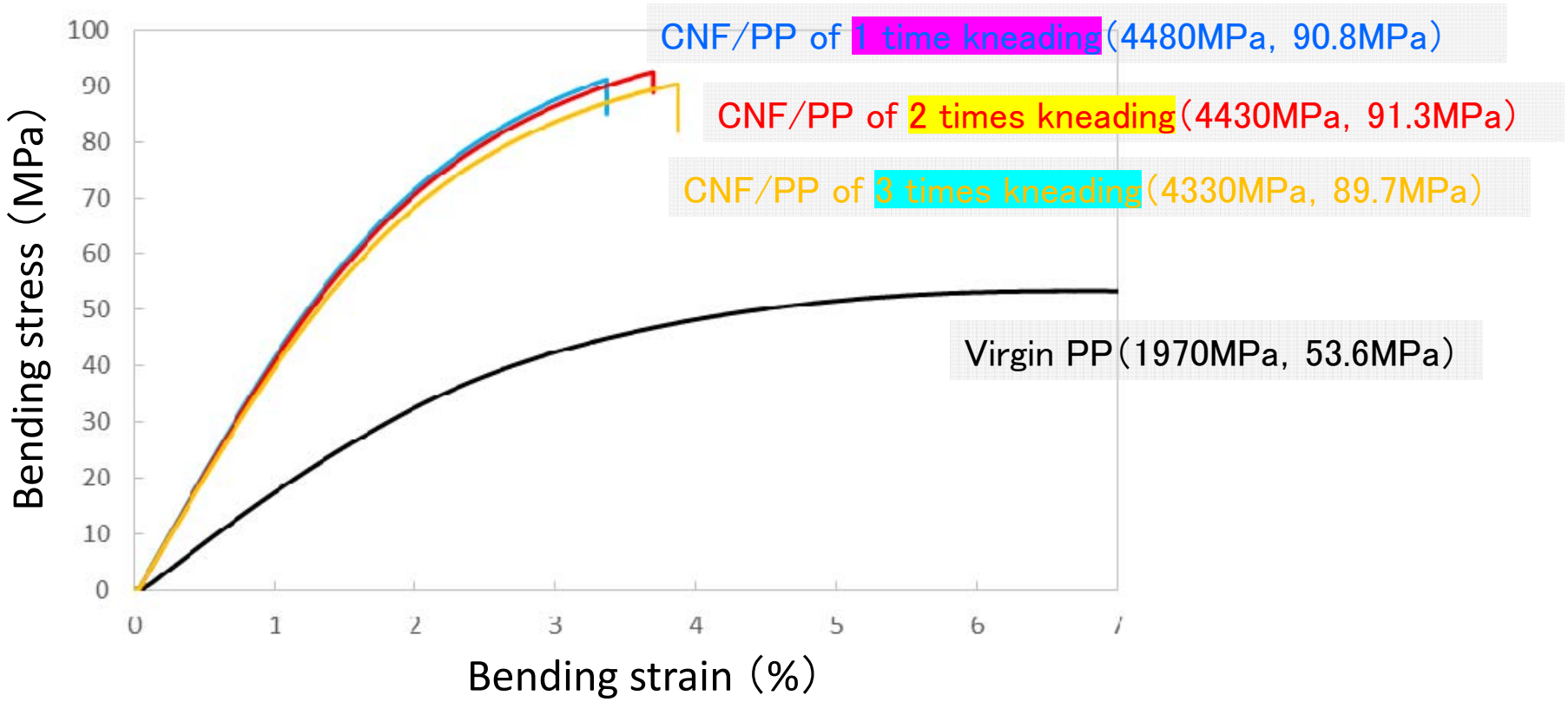


Coefficient of thermal expansion(CTE) (0-100℃)



Material recycling of CNF-10wt%/PP composite

Bending stress-strain curve of repetition of extrusion

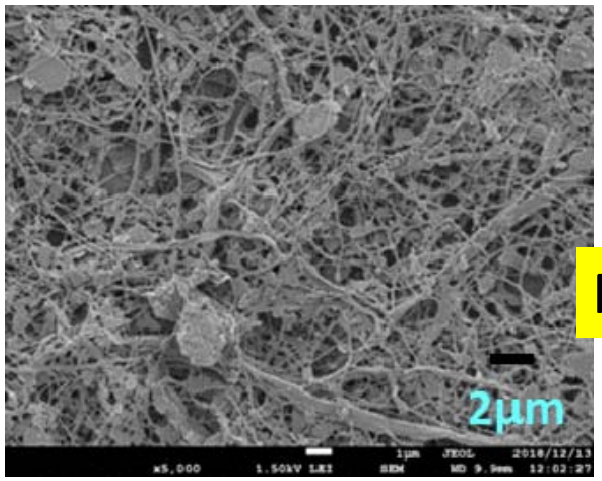


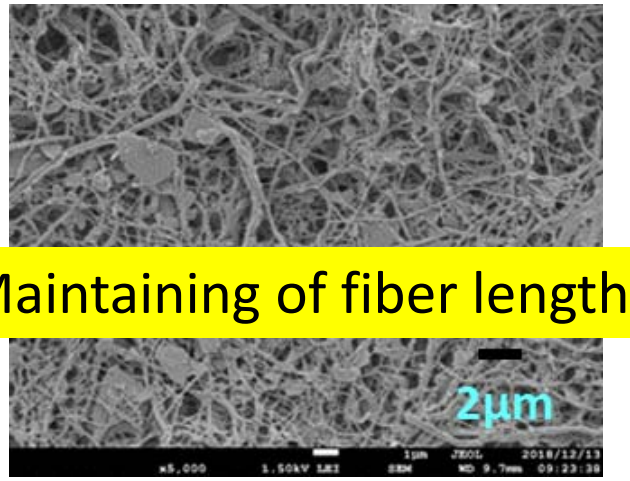
Reduction of bending properties is little by material recycling

Material recycling of CNF-10wt%/PP composite

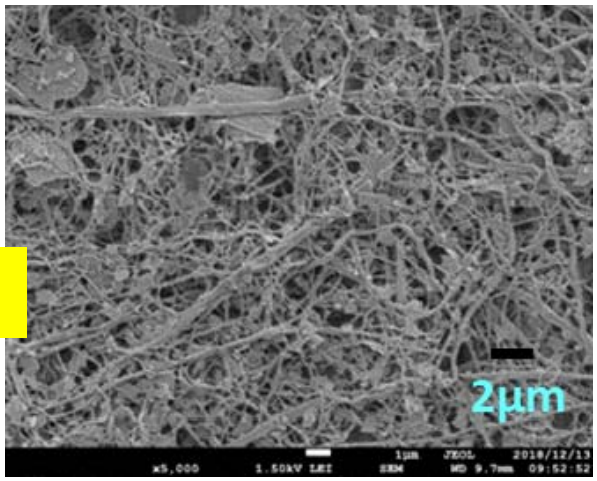
1 time kneading | 2 times kneading | 3 times kneading

CNF

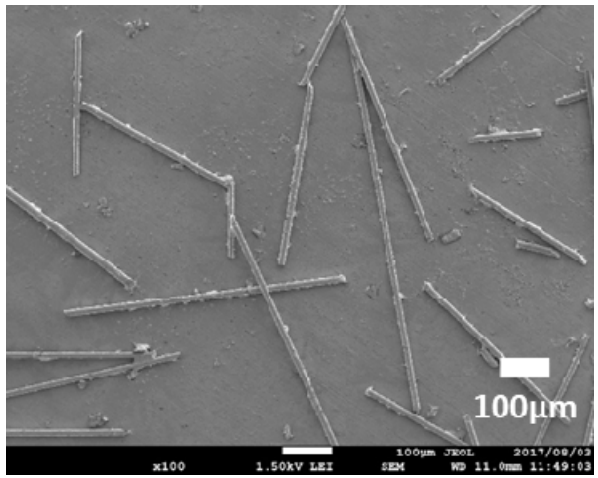


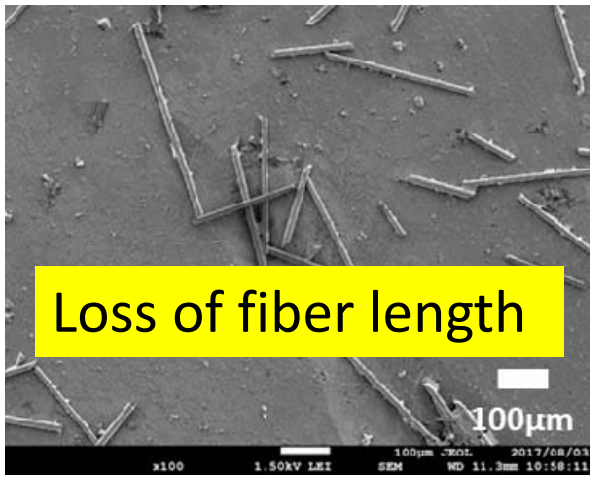


Maintaining of fiber length

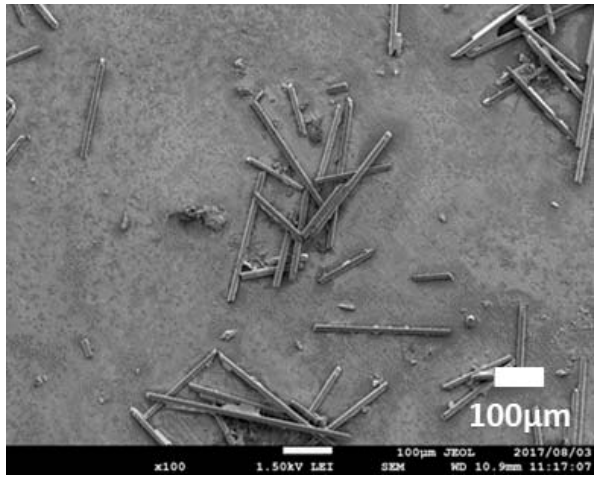


Glass fiber

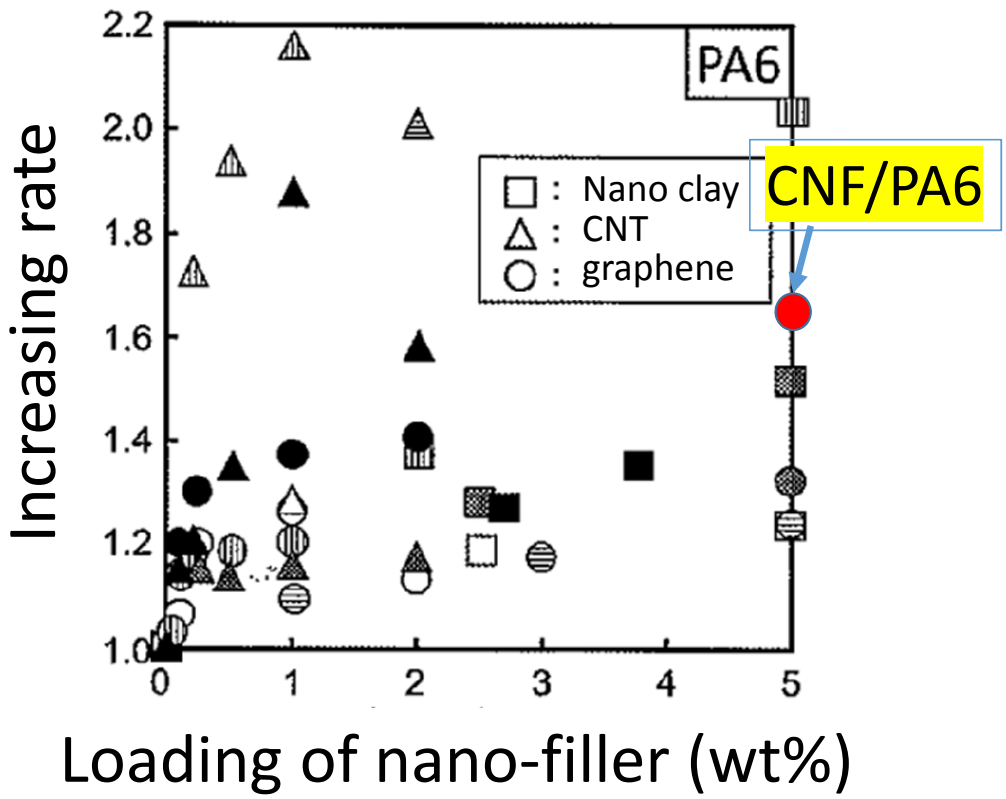


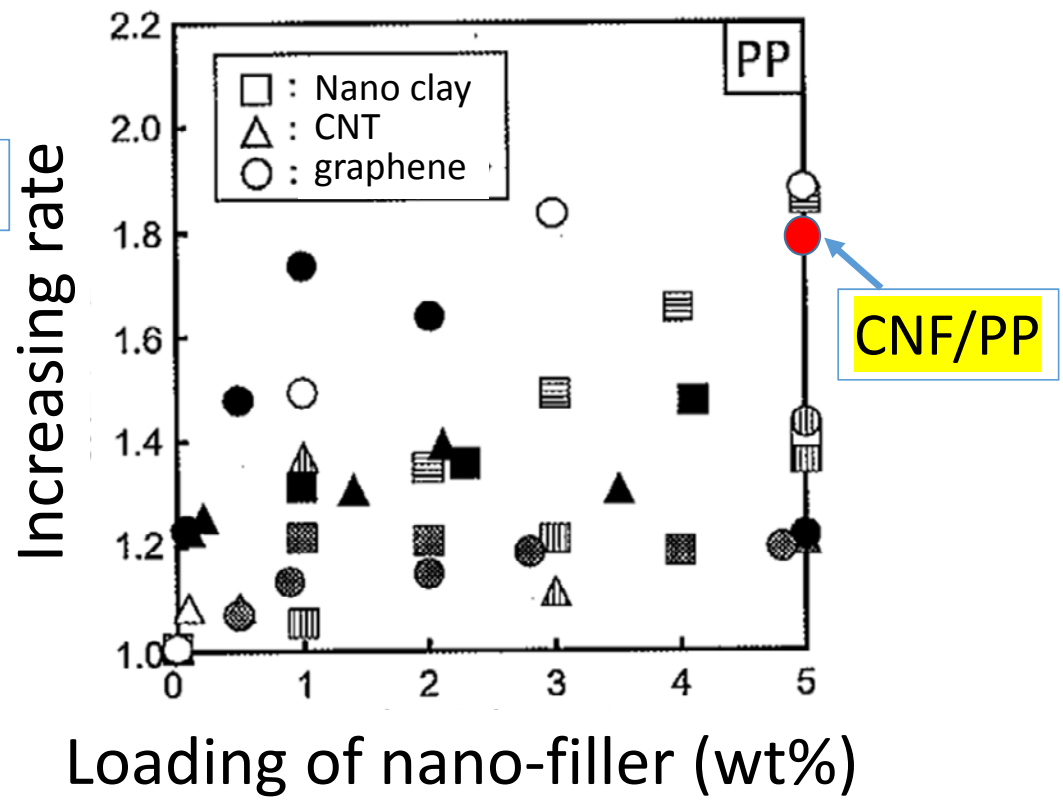


Loss of fiber length



Conclusion: Comparison between the CNF/PA6, PP and nano-composites





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Thank you

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