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NYLON-12 NANOCOMPOSITE THIN FILMS AS PROTECTIVE BARRIERS

by

Dr. Cecilia L. Stevens, Polymer Engineering Company

Dr. Marek J. Gnatowski, Polymer Engineering Company

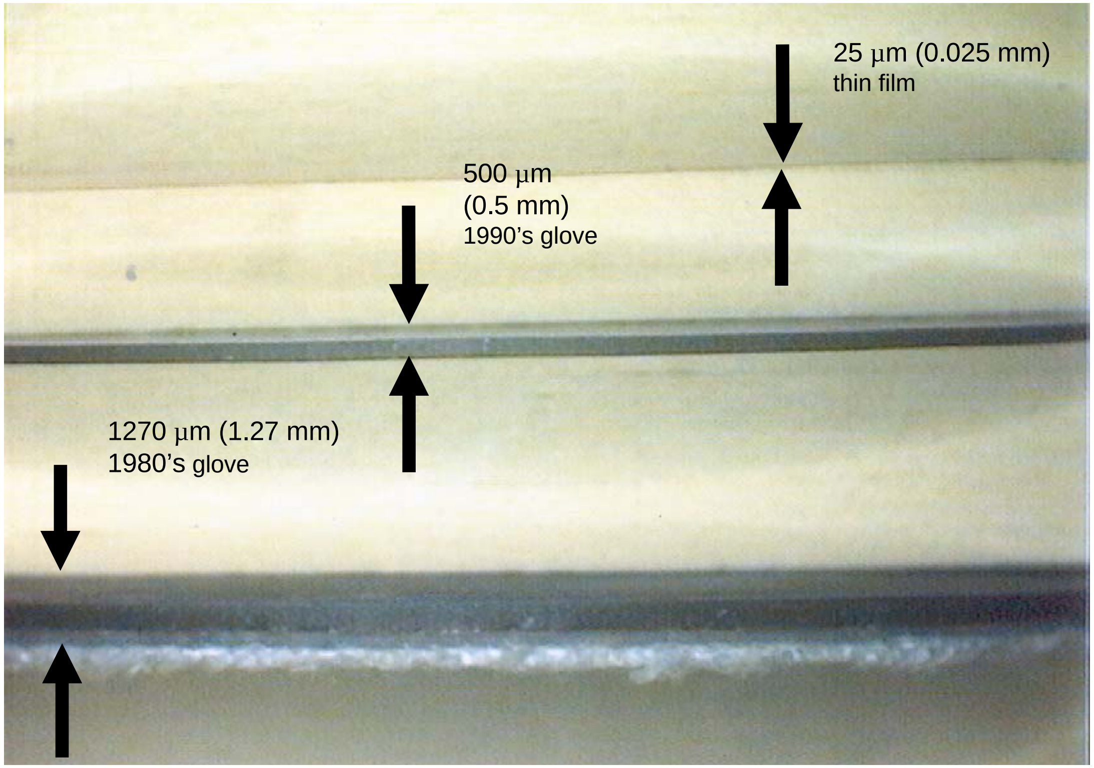
Dr. Scott Duncan, Defence Research and Development Canada

Concept product example

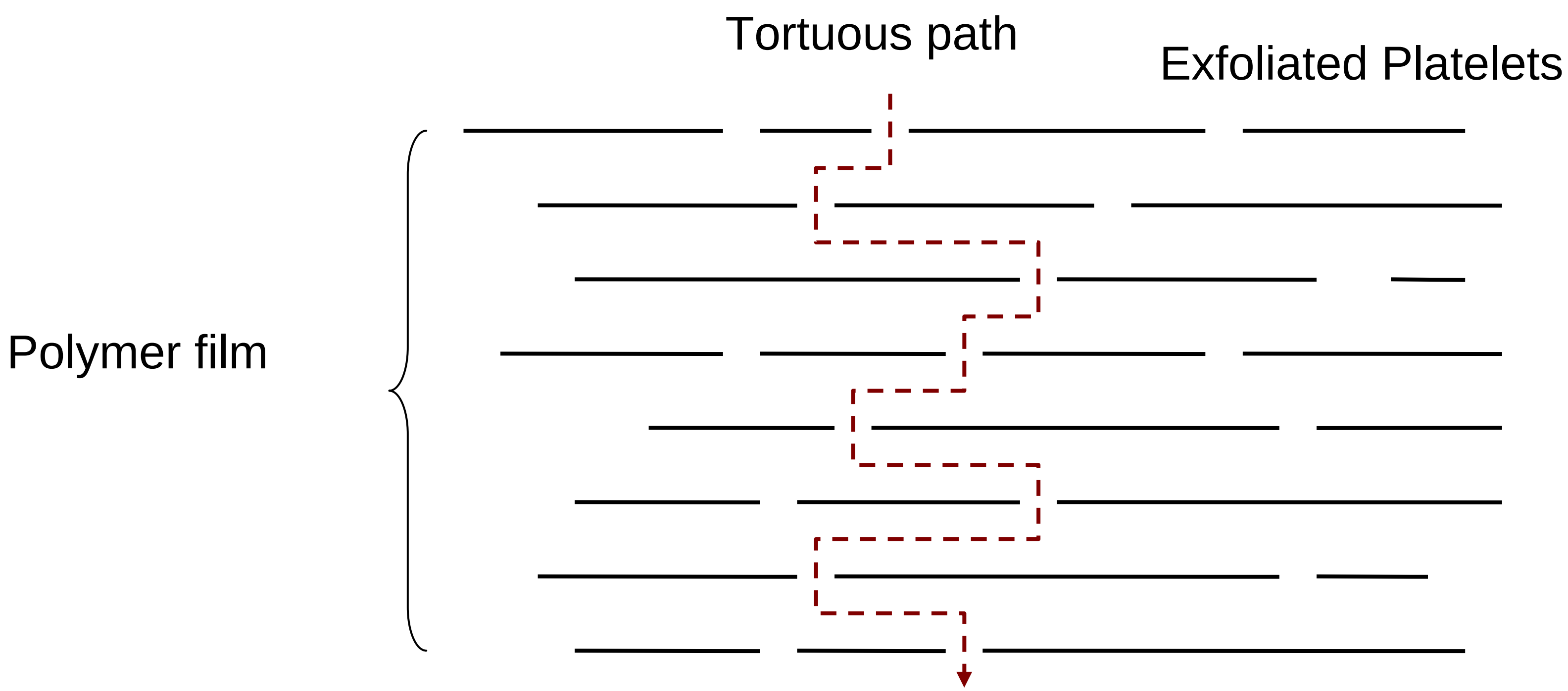
Current technology

Target technology

Thicknesses of barrier films: an evolution

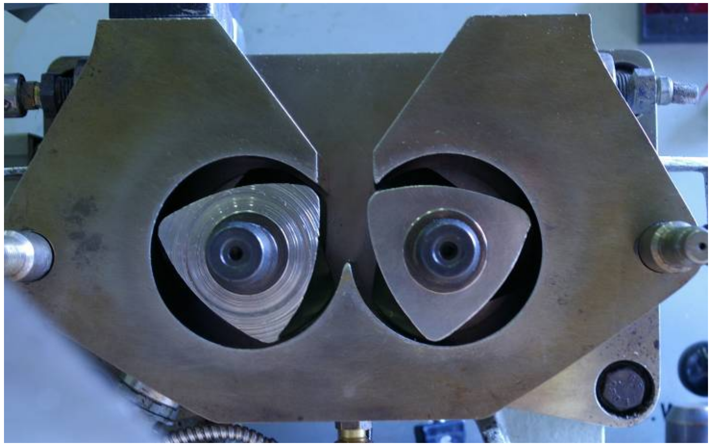


Tortuous path theorem

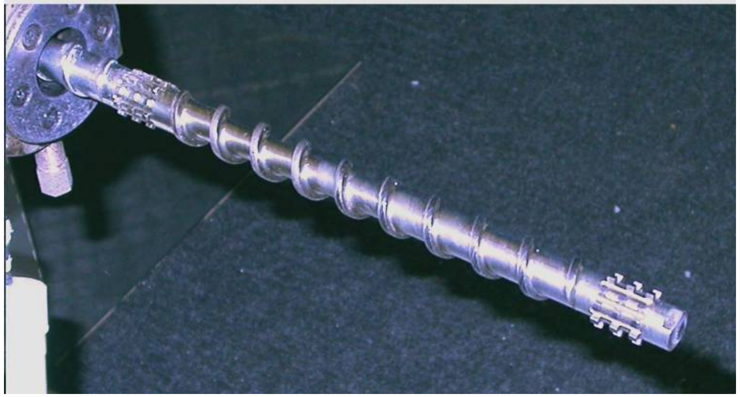


$$\tau = 1 + \left(\frac{L}{2W} \right) V_f$$

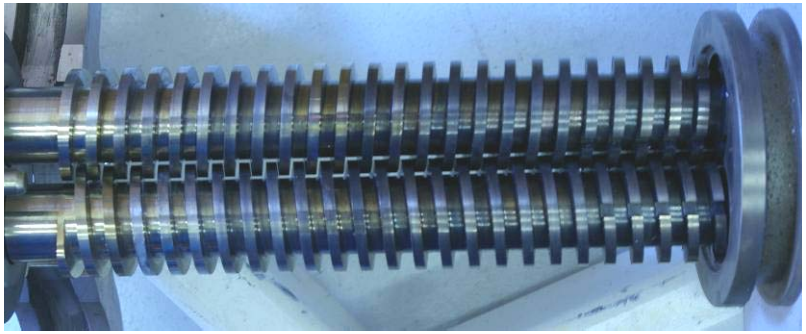
Equipment used for sample blending: potential differences in performance



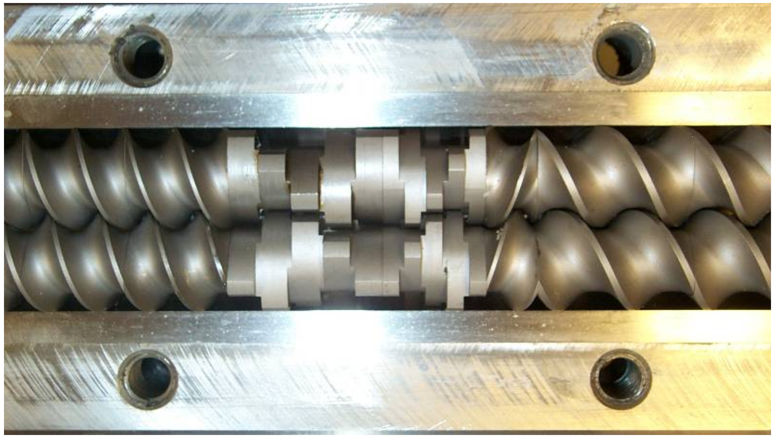
Batch blender (BB)



Single-screw extruder (SS)

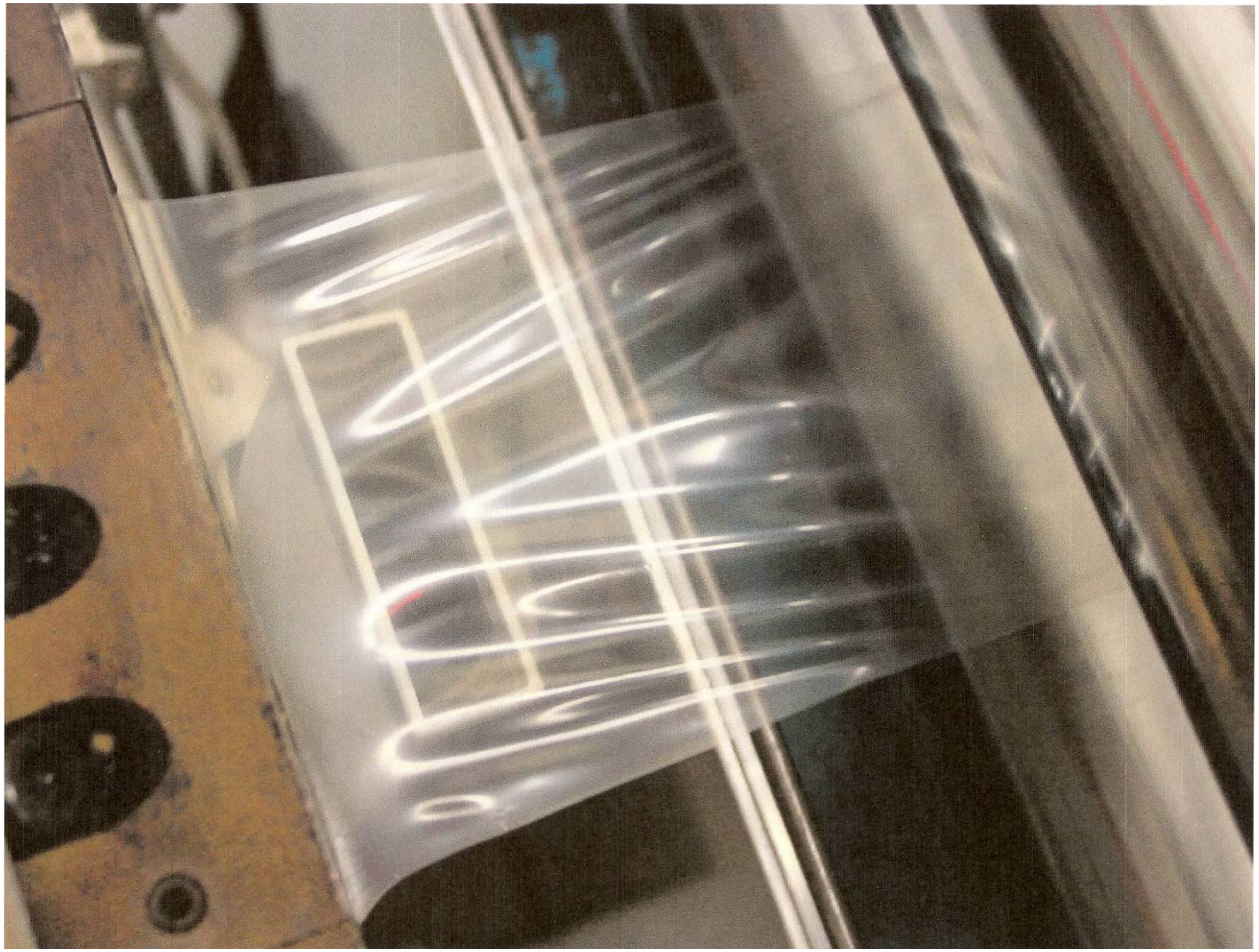


Compounding twin-screw (D6/2)

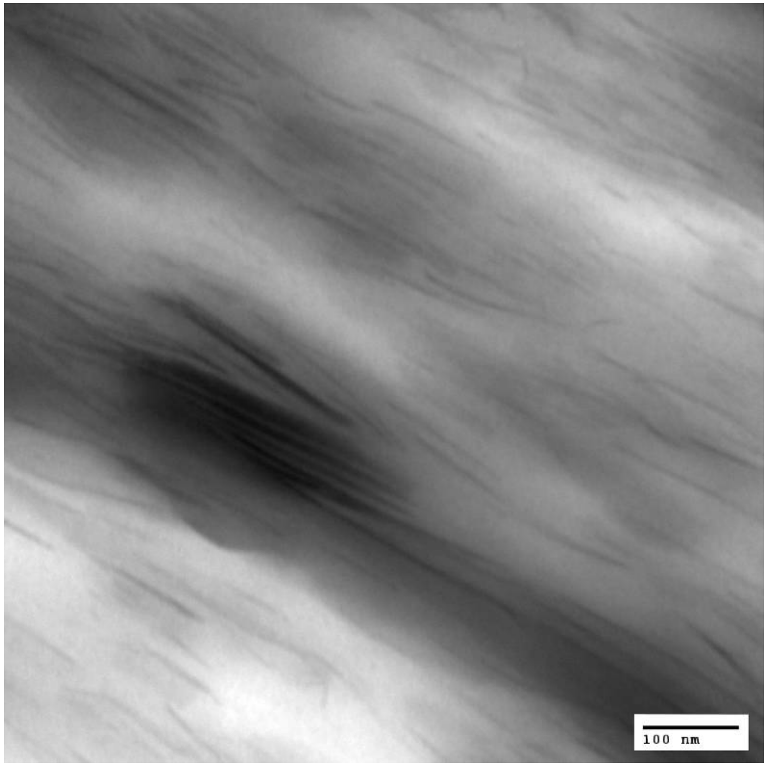


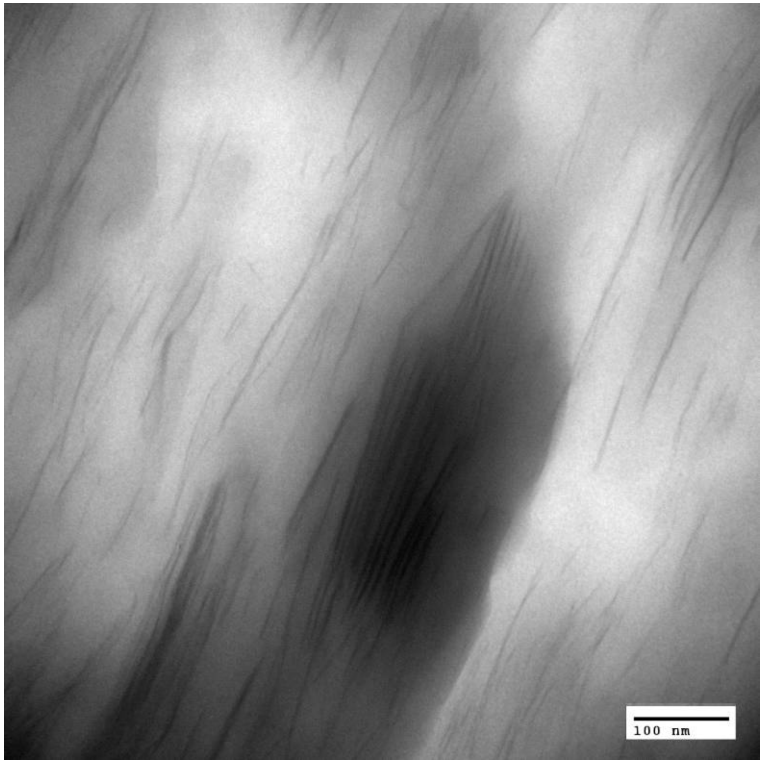
Twin-screw extruder (TSE)

Film casting



TEM images (1):
Exfoliation issues

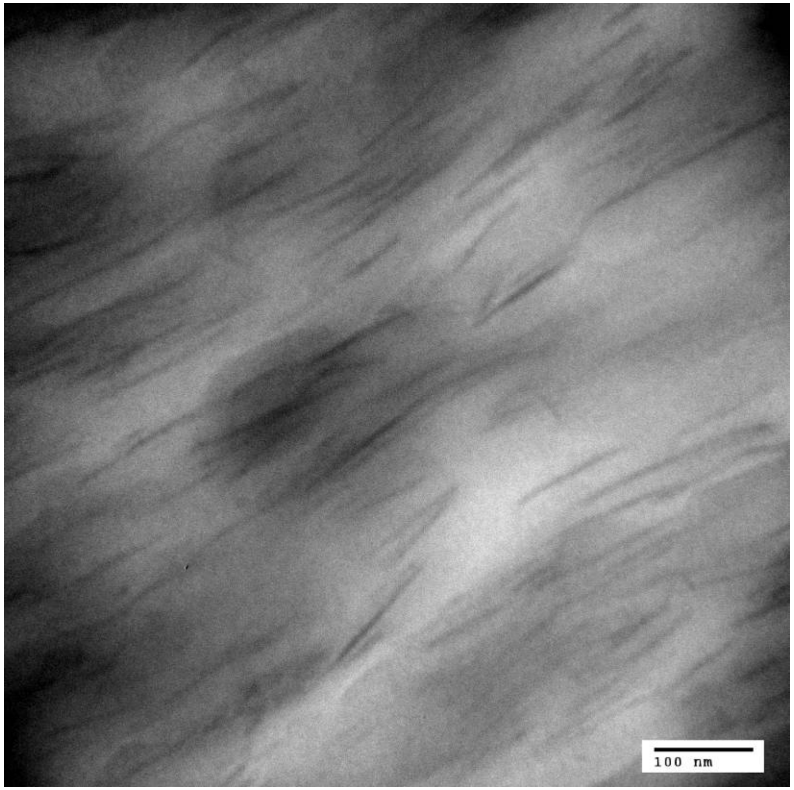




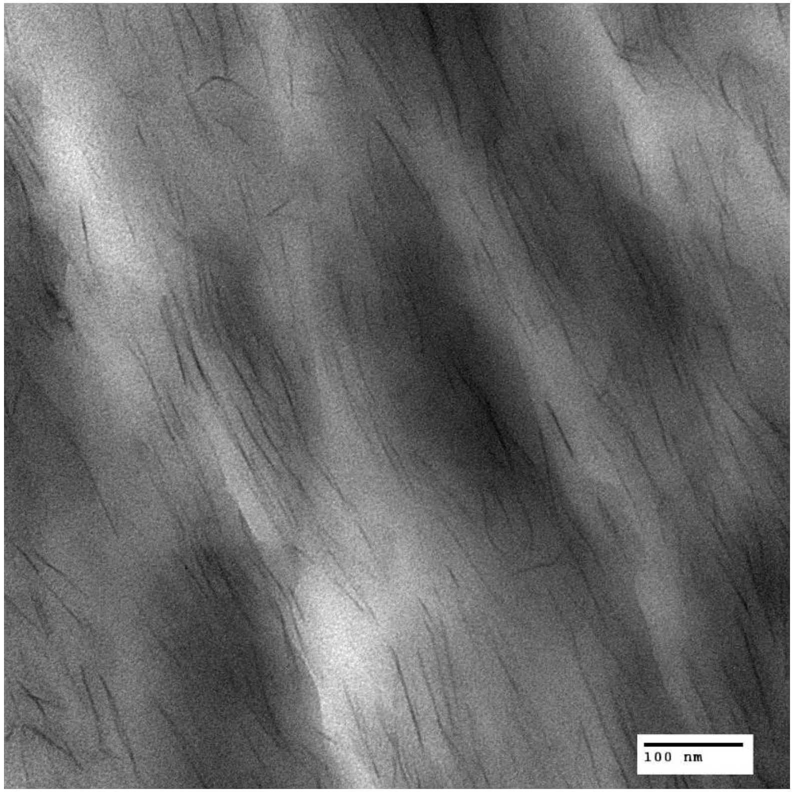
BB

SS

TEM images (2)

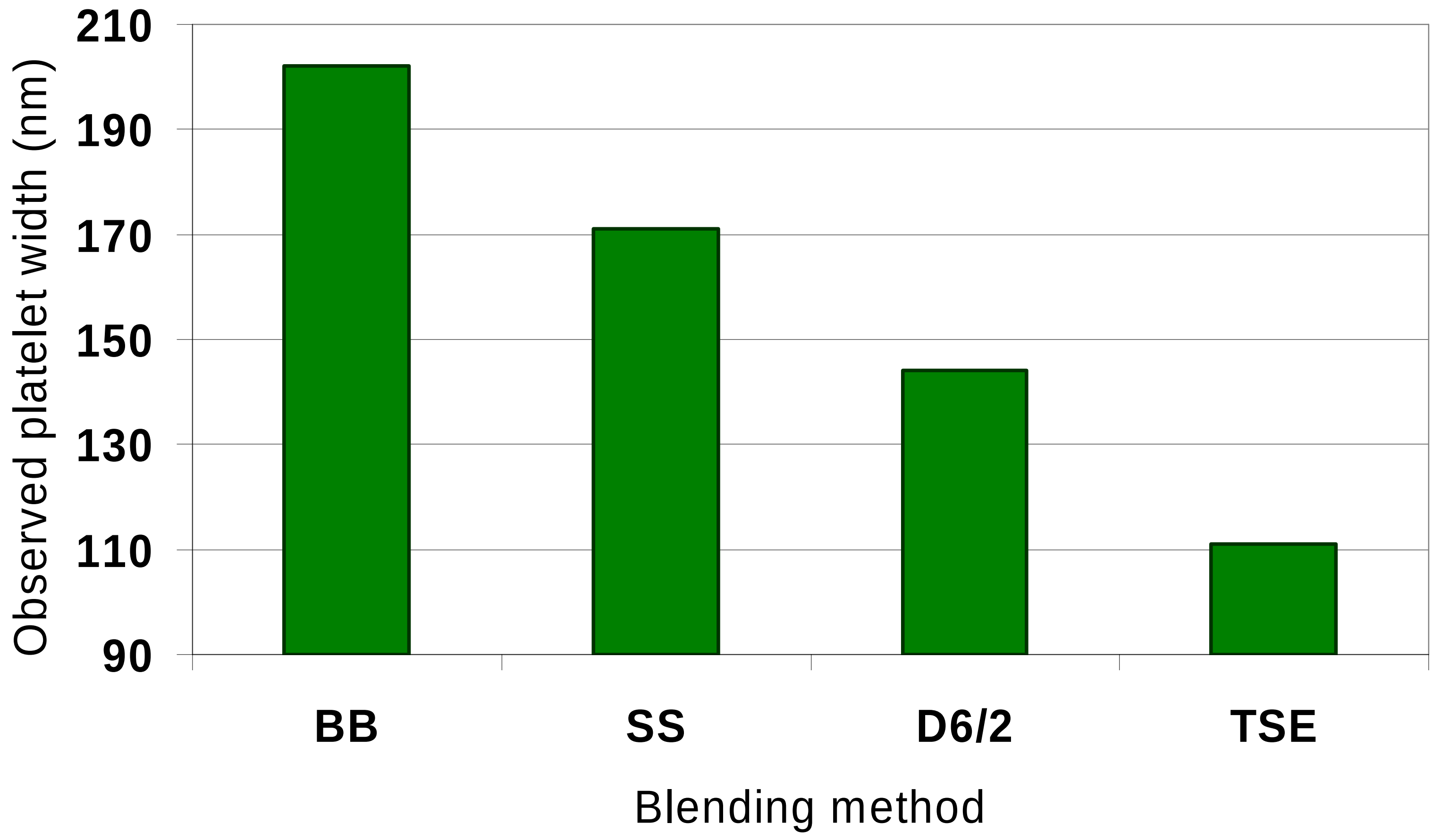


D6/2

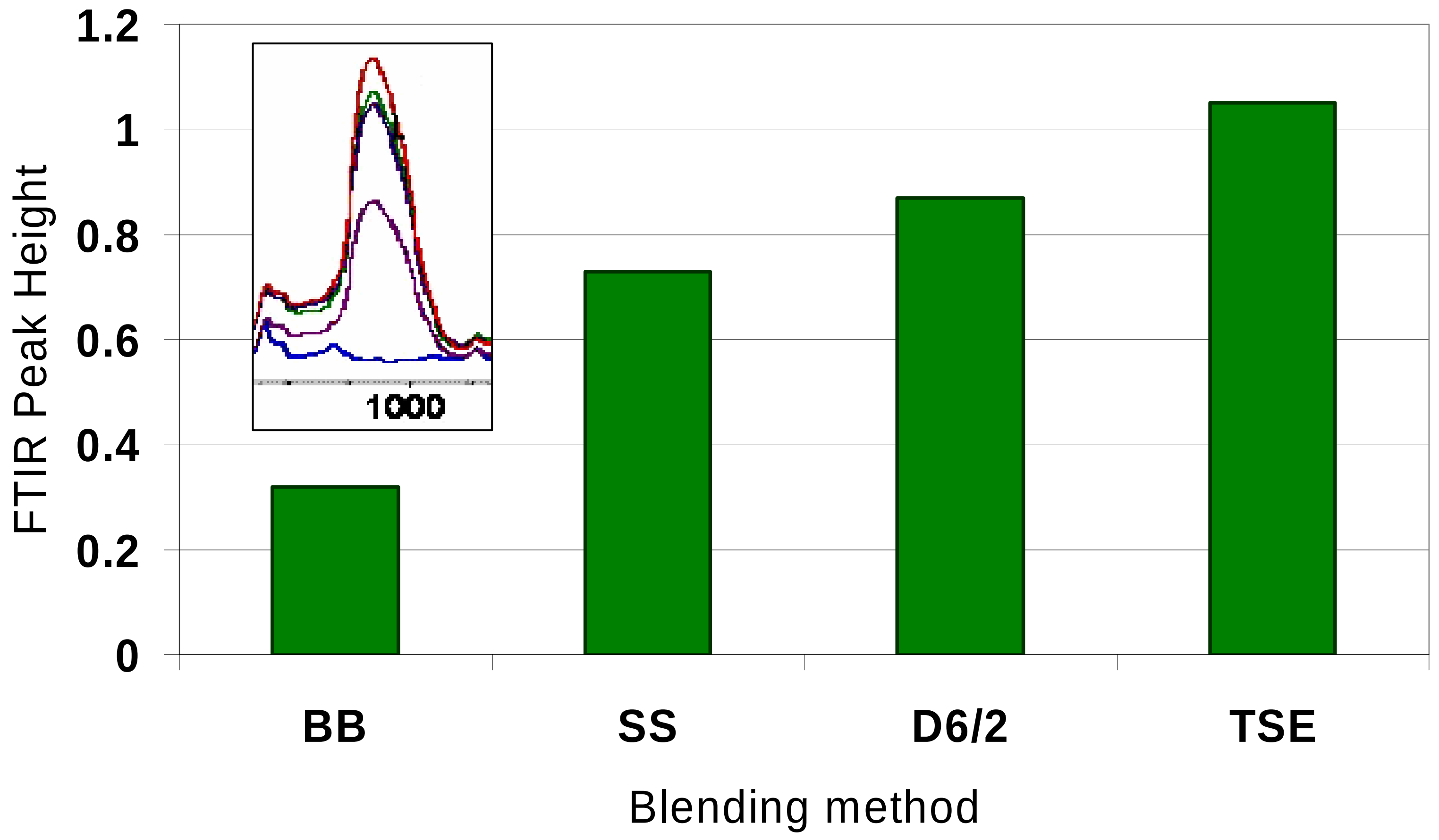


TSE

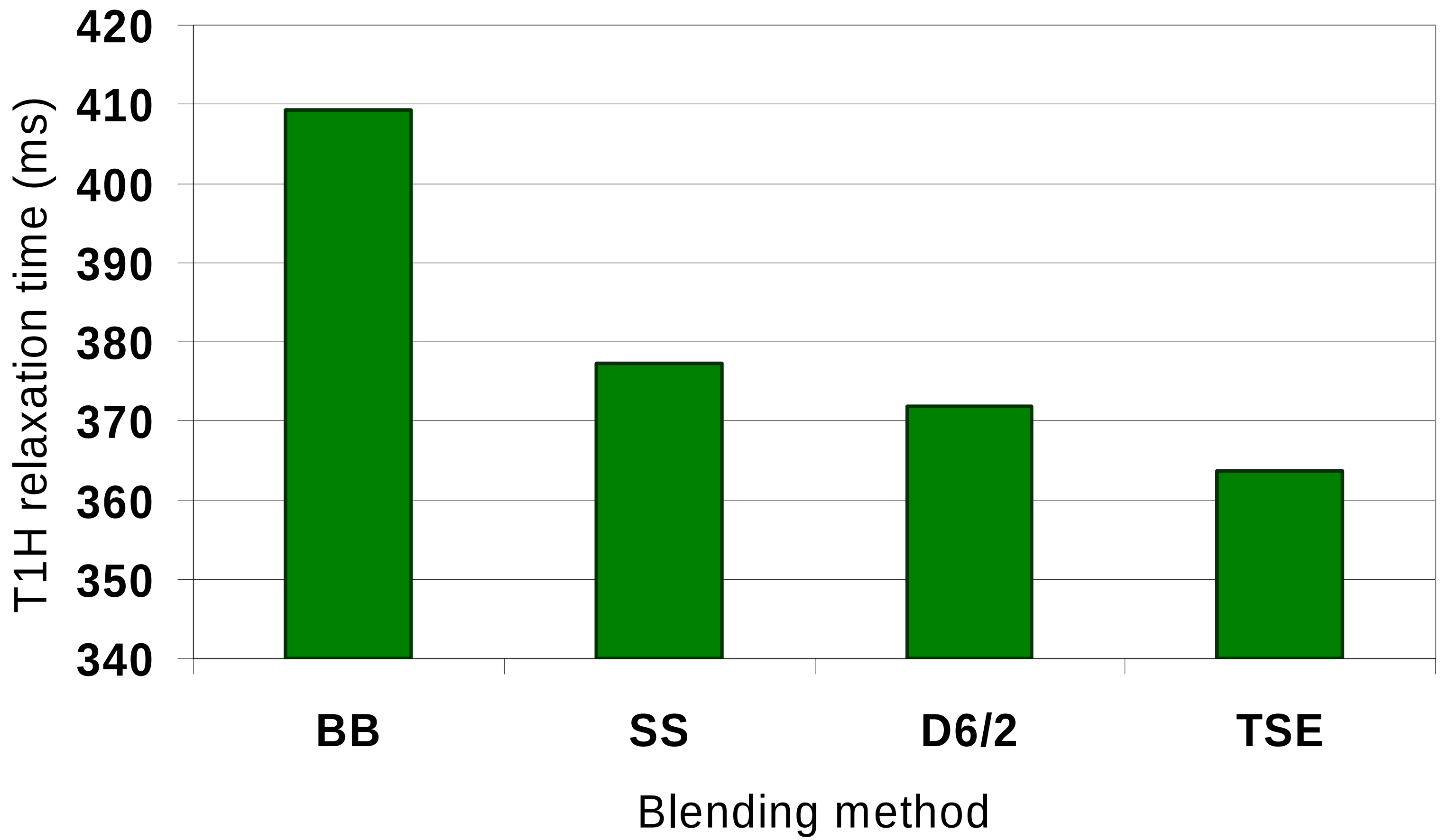
Platelet width:
‘greater shear’ gives smaller platelets



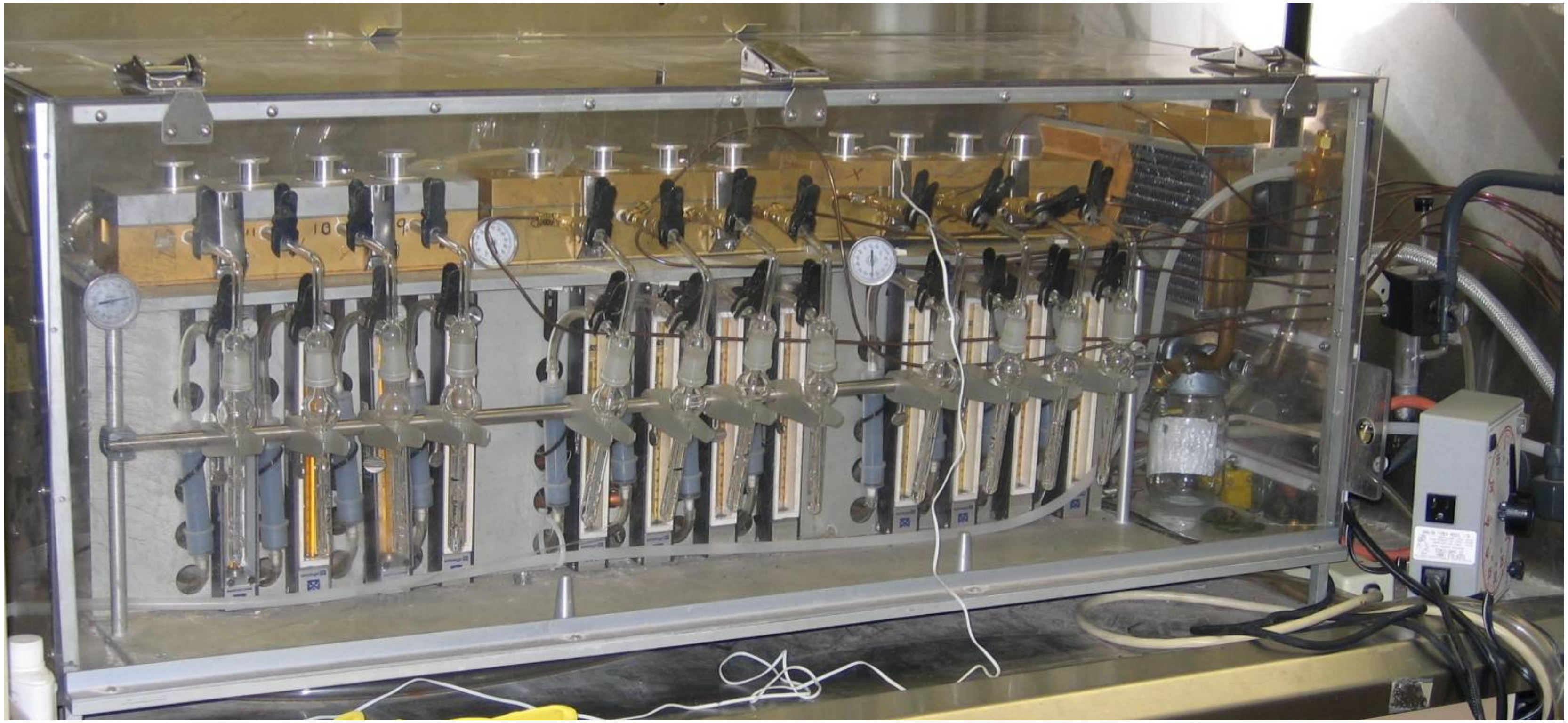
FTIR clay peak:
greater shear gives a higher peak



SSNMR:
greater shear gives better dispersion and a lower T_1^H relaxation time

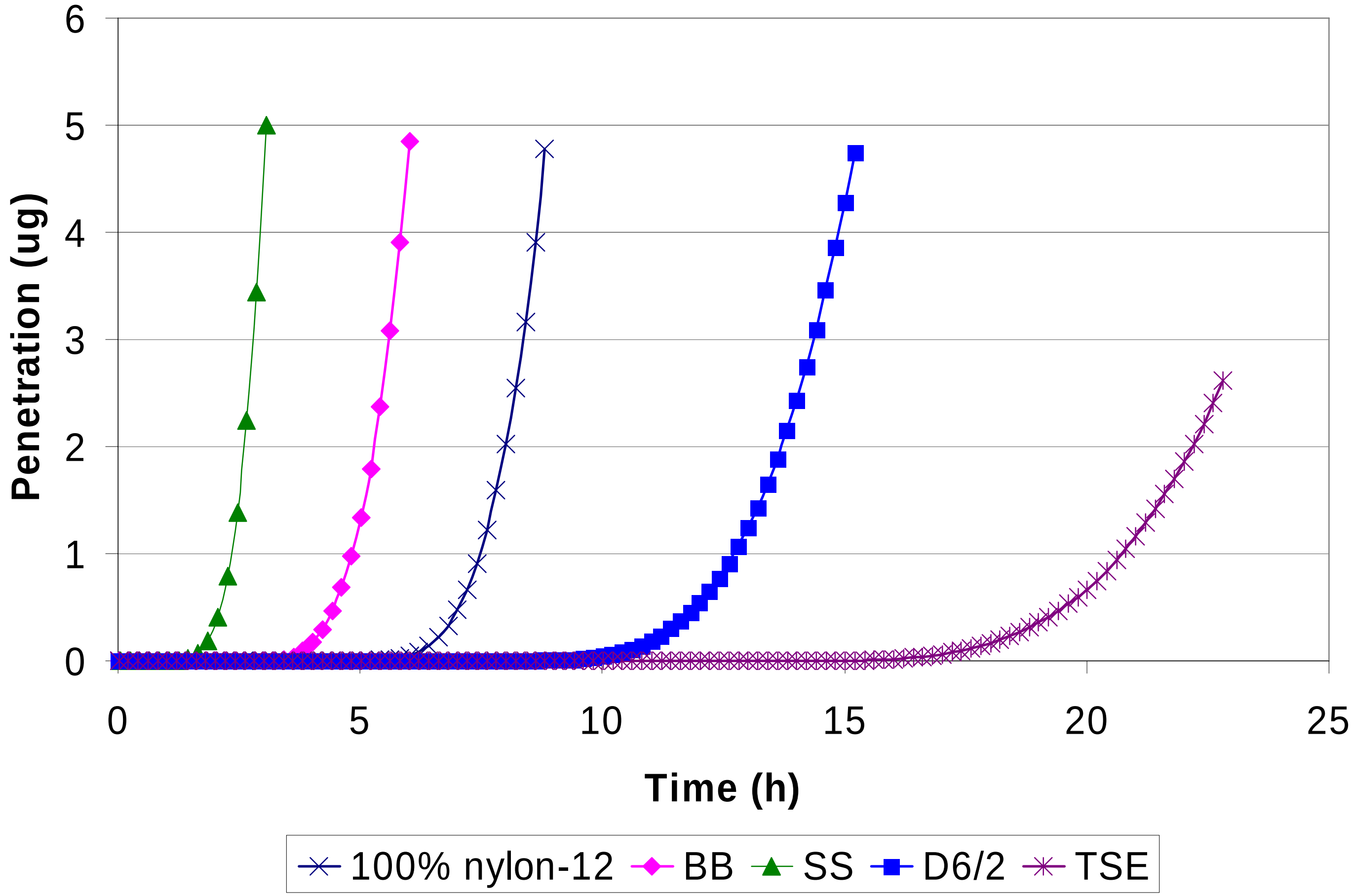


Penetration and re-emission testing



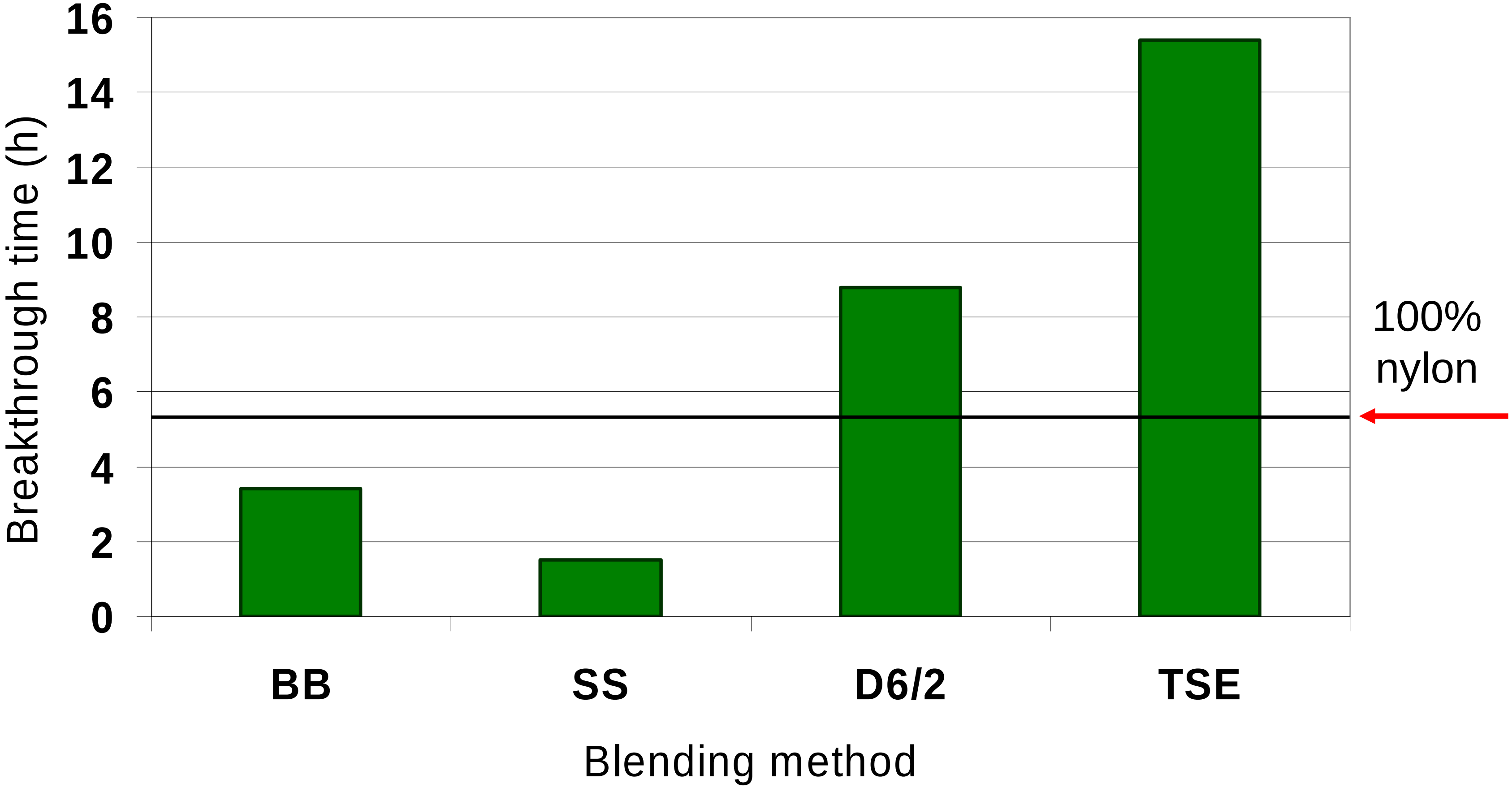
Nylon-12 had no detectable re-emission of sulphur mustard in 24 hours.

Penetration curves

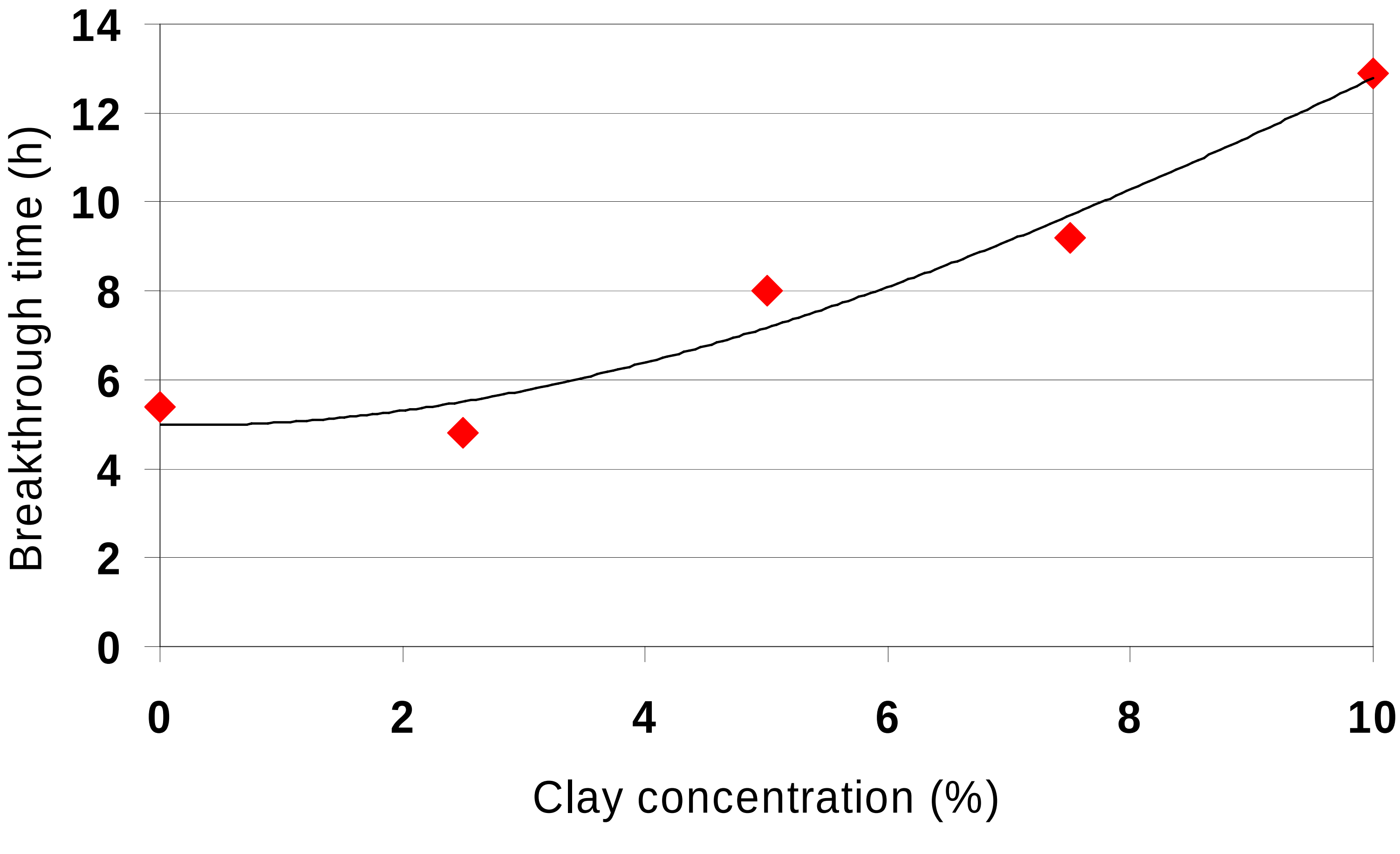


Breakthrough time:

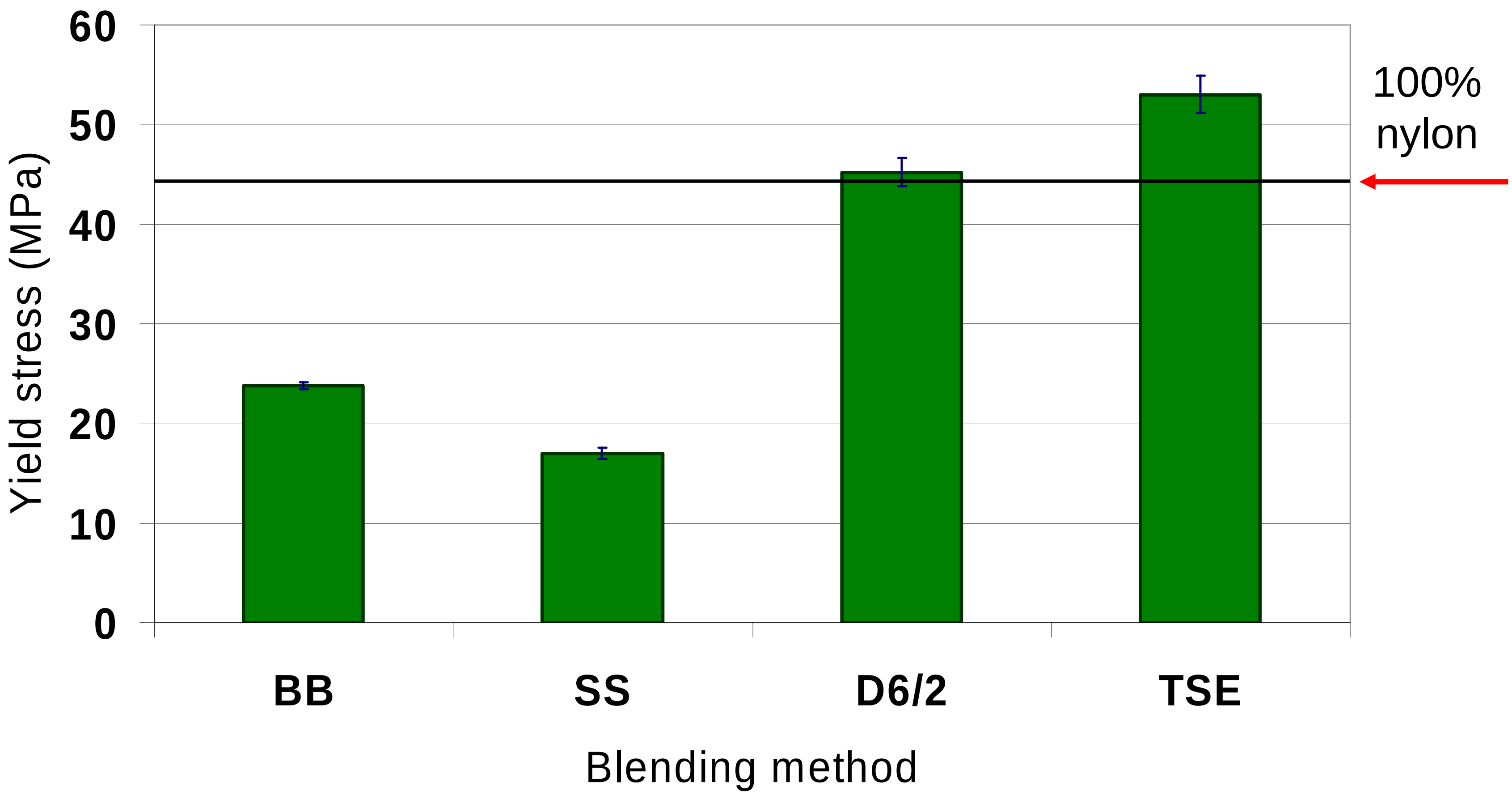
strongly affected by exfoliation; not directly correlated to dispersion



Breakthrough time: dependent on clay loading

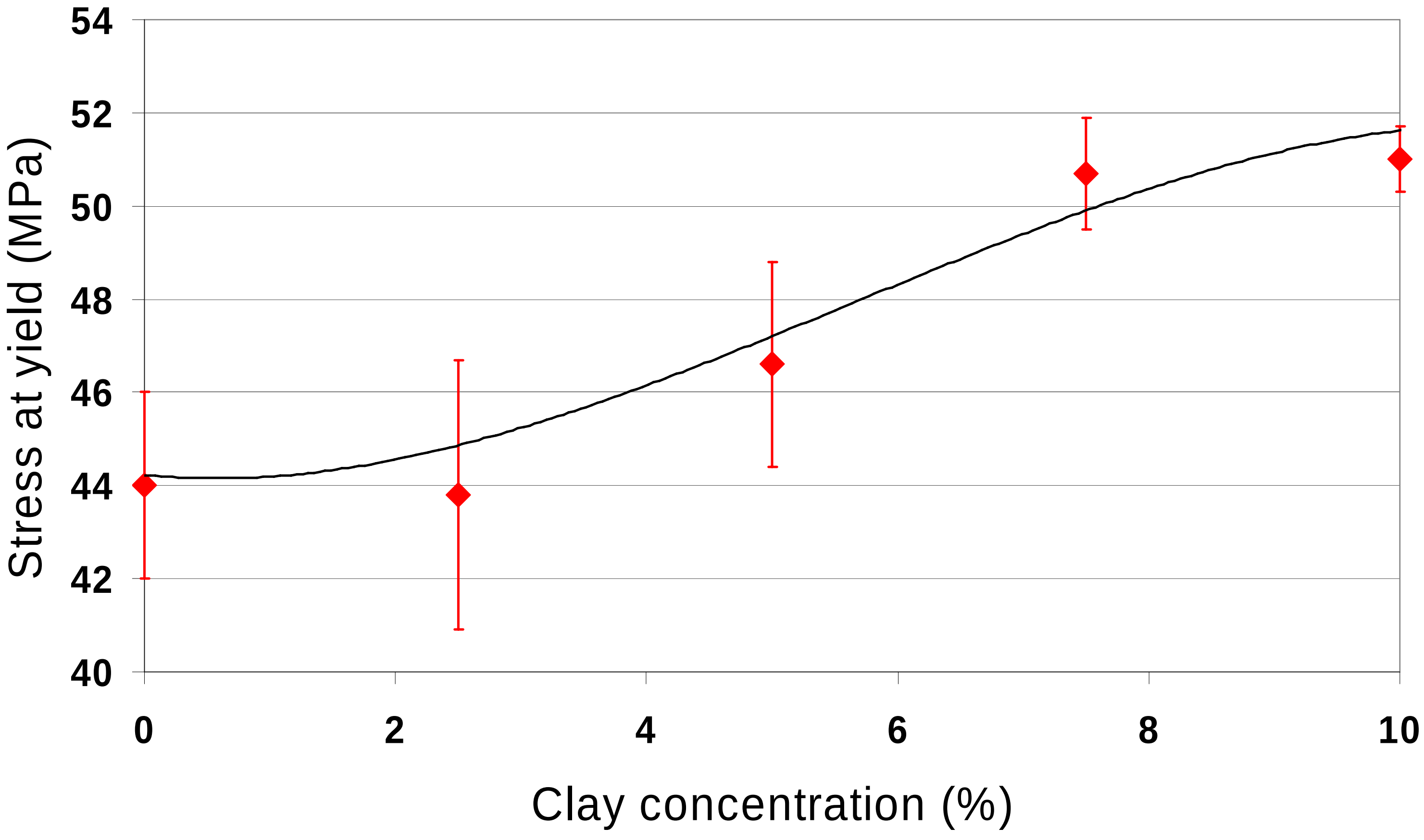


Tensile strength:
Not directly dependent on dispersion.

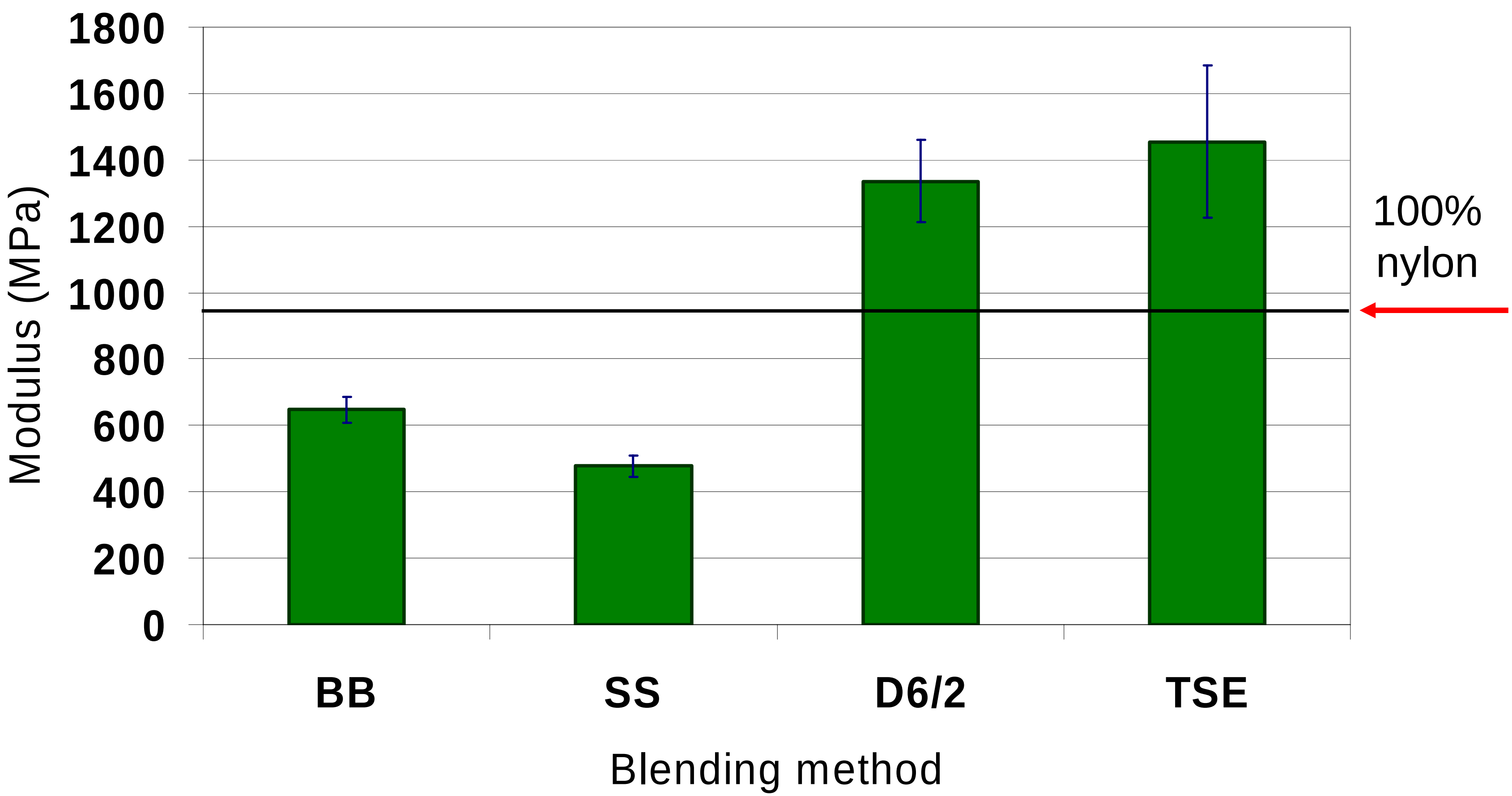


*Apparent correlation to breakthrough time is deceptive.

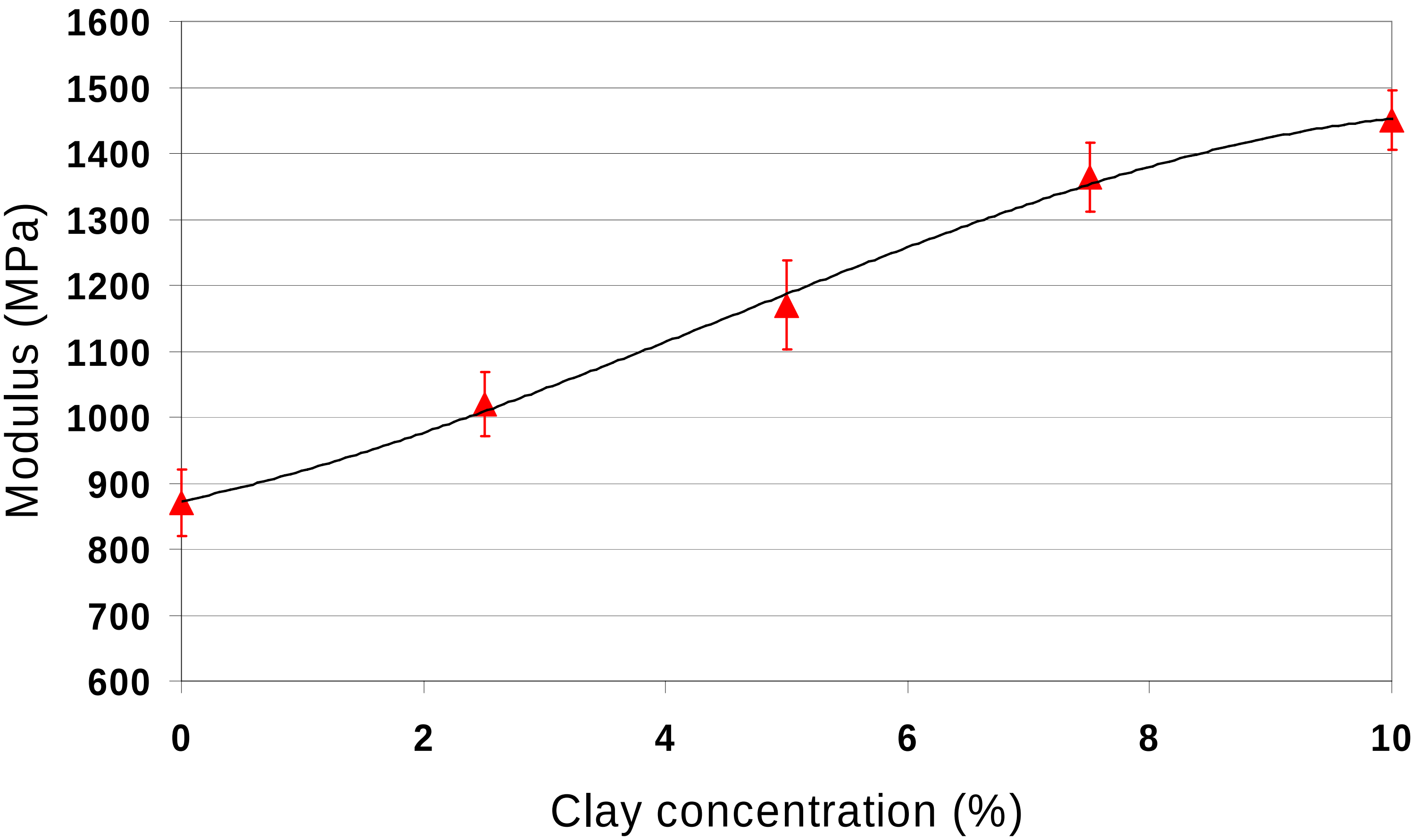
Tensile strength: responsive to clay loading



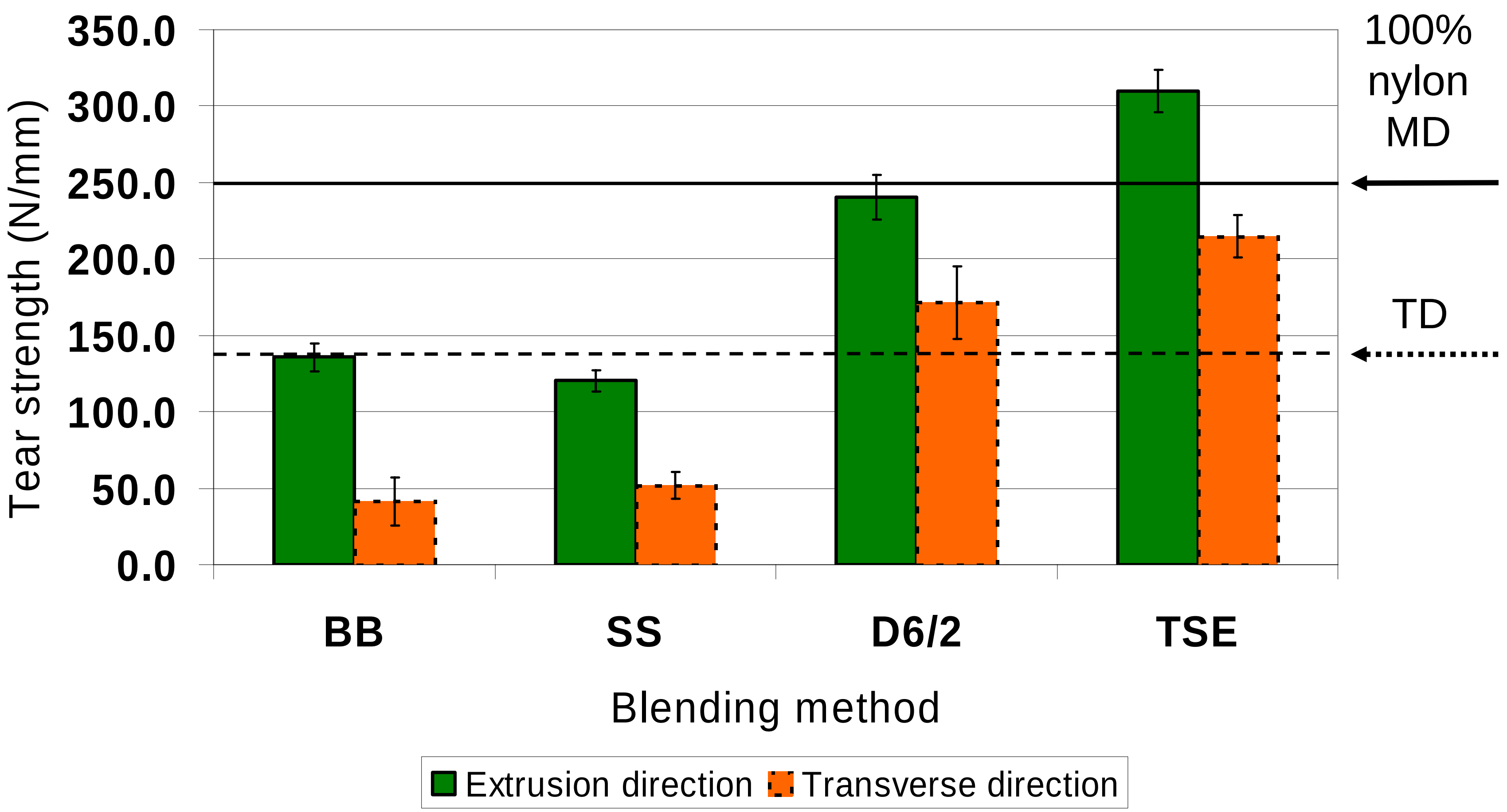
Tensile Modulus (stiffness): Similar to tensile strength



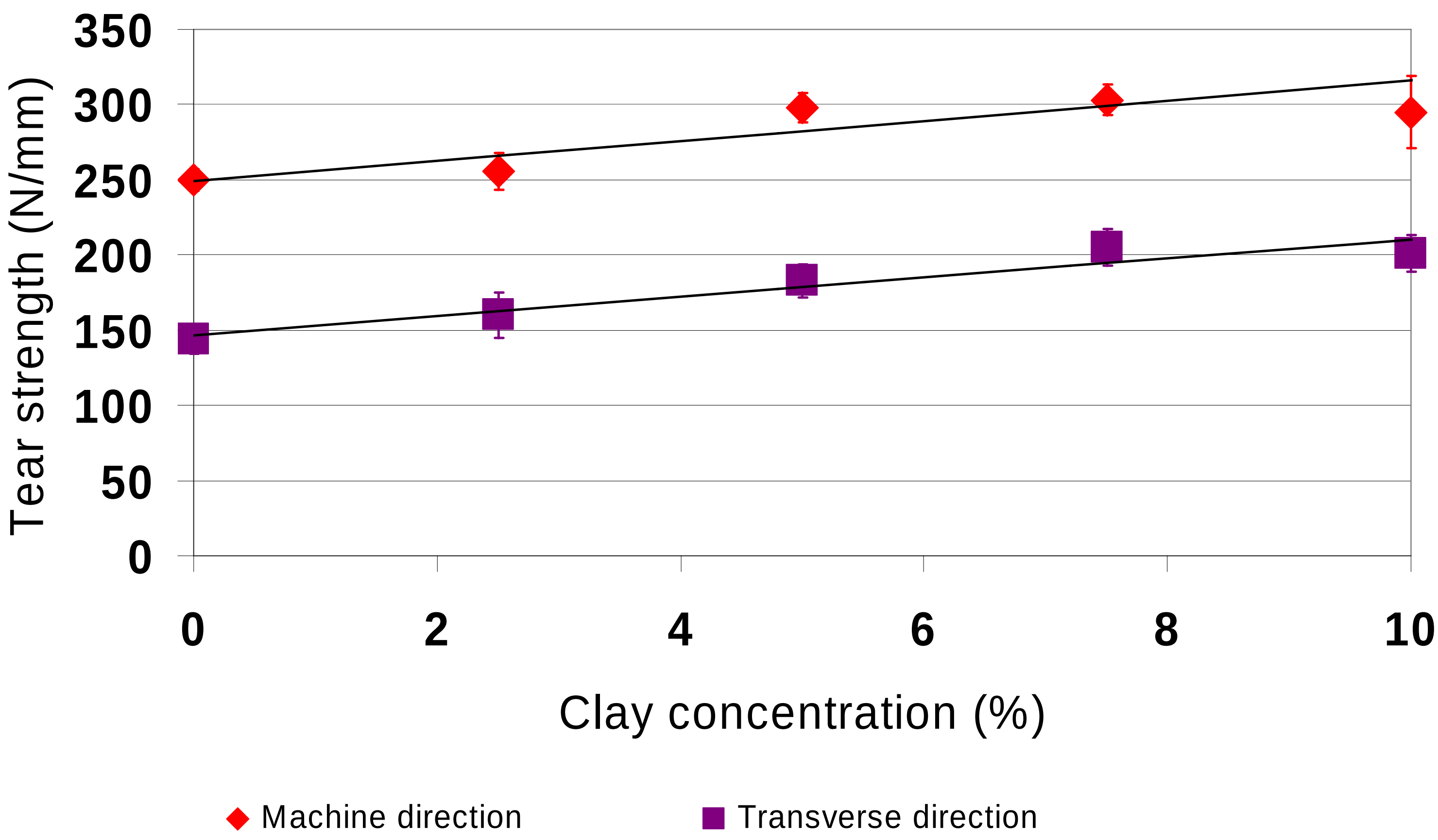
Tensile Modulus (stiffness): increases with clay loading



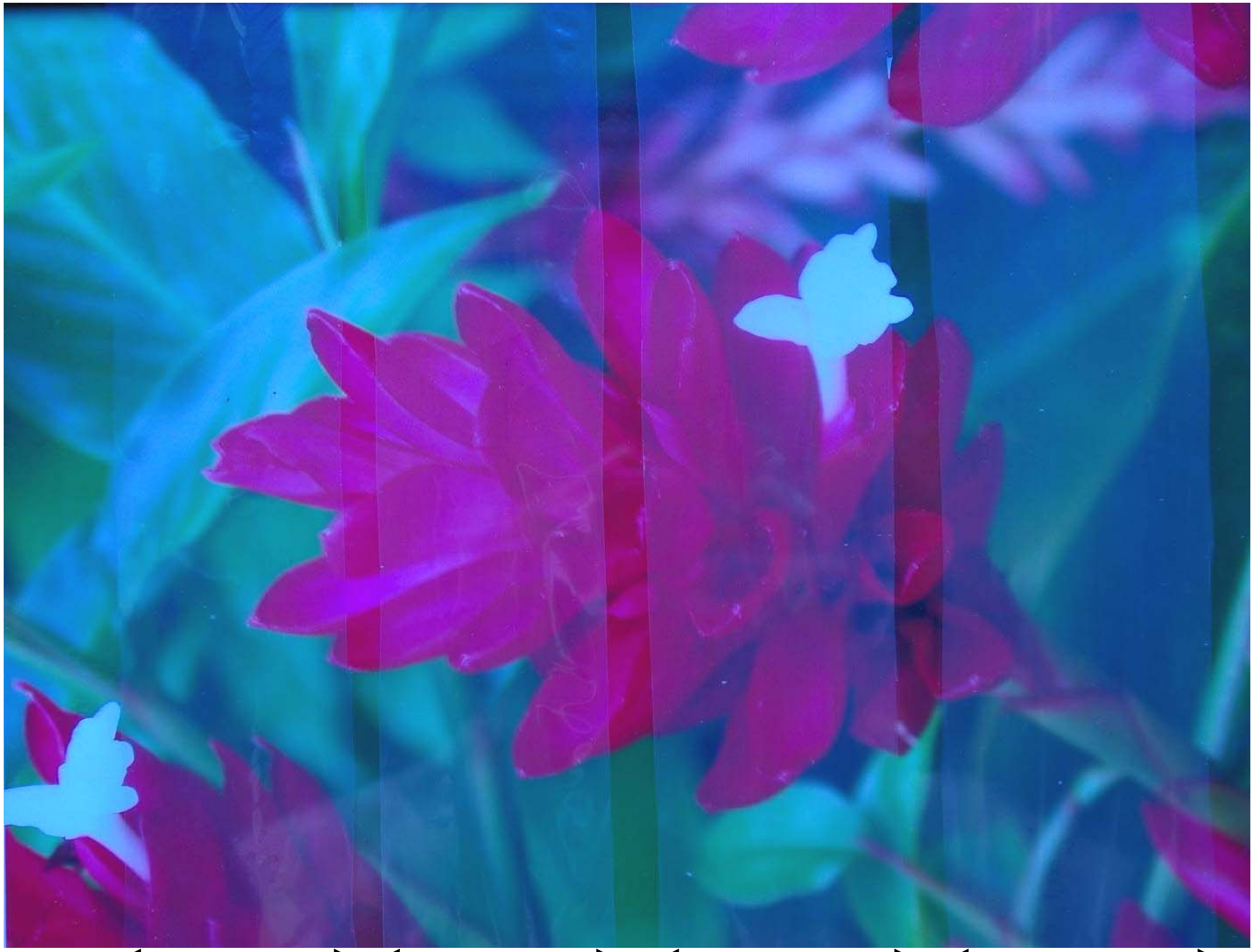
Tear strength:
Similar to tensile strength and modulus



Tear strength:
increases slightly with clay loading



Transparency



2.5% clay 5.0% clay 7.5% clay 10.0% clay

Conclusions

- Nylon-12 is a suitable material for use in warfare agent barrier technology.
- Montmorillonite nanoclay can greatly improve the barrier and mechanical properties of nylon-12 thin films.
- Effective exfoliation and dispersion of the clay is critical to the film performance.
- Dispersion, barrier properties, and mechanical properties are not directly related.
- Optimal clay loading may be below 10%.
- Optical transparency is excellent even at 10% clay loading

Acknowledgements

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