Toughened Resin Infusion System with Soluble Veil Technology

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Cytec Engineered Materials

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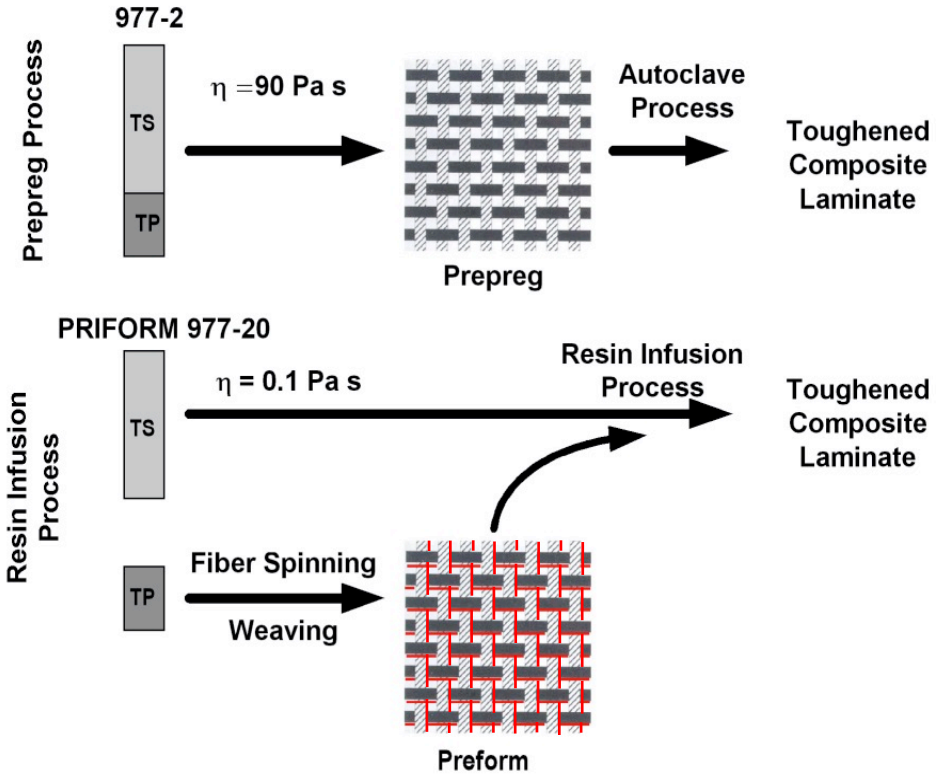
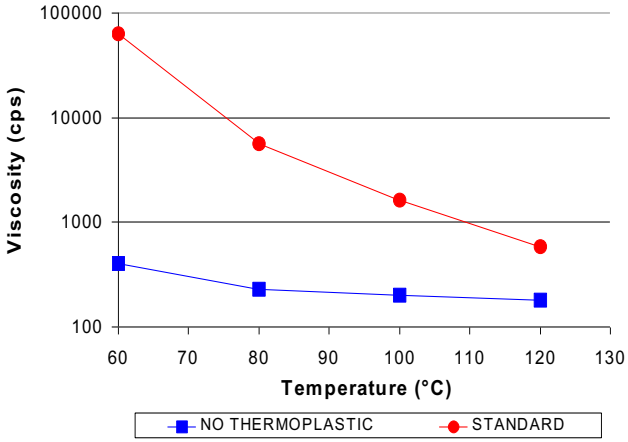
Resin Infusion Technologies

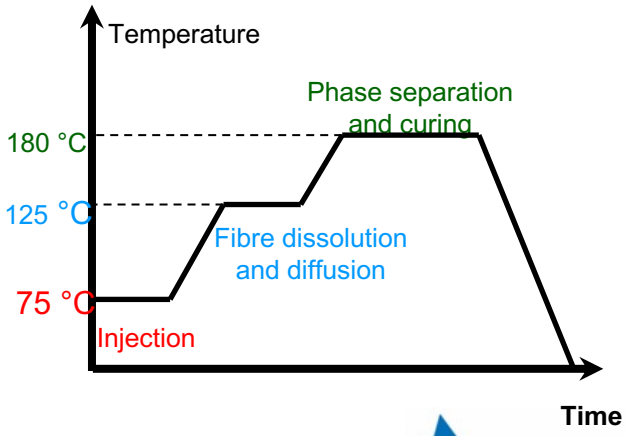
- Key Advantages
  - –Enables use of advanced textile reinforcements
  - –Geometry Integration
- But potential is not fully realized due to
  - –Poor toughness
  - –Preforming difficulties
  - –Lower mechanical properties of fabrics & braids relative to UD tape
- Ways to toughen infusion resins & disadvantages
  - –Particle toughened – filtering & washouts
  - –High MW monomer toughened – higher viscosity

PRIFORM: Interwoven Soluble Fiber

Incorporation of multi-functional soluble fibers into the preform allows for low viscosity infusion while obtaining high toughness and FST properties. The soluble fibers can also be used to build the preform, i.e. as a binder.

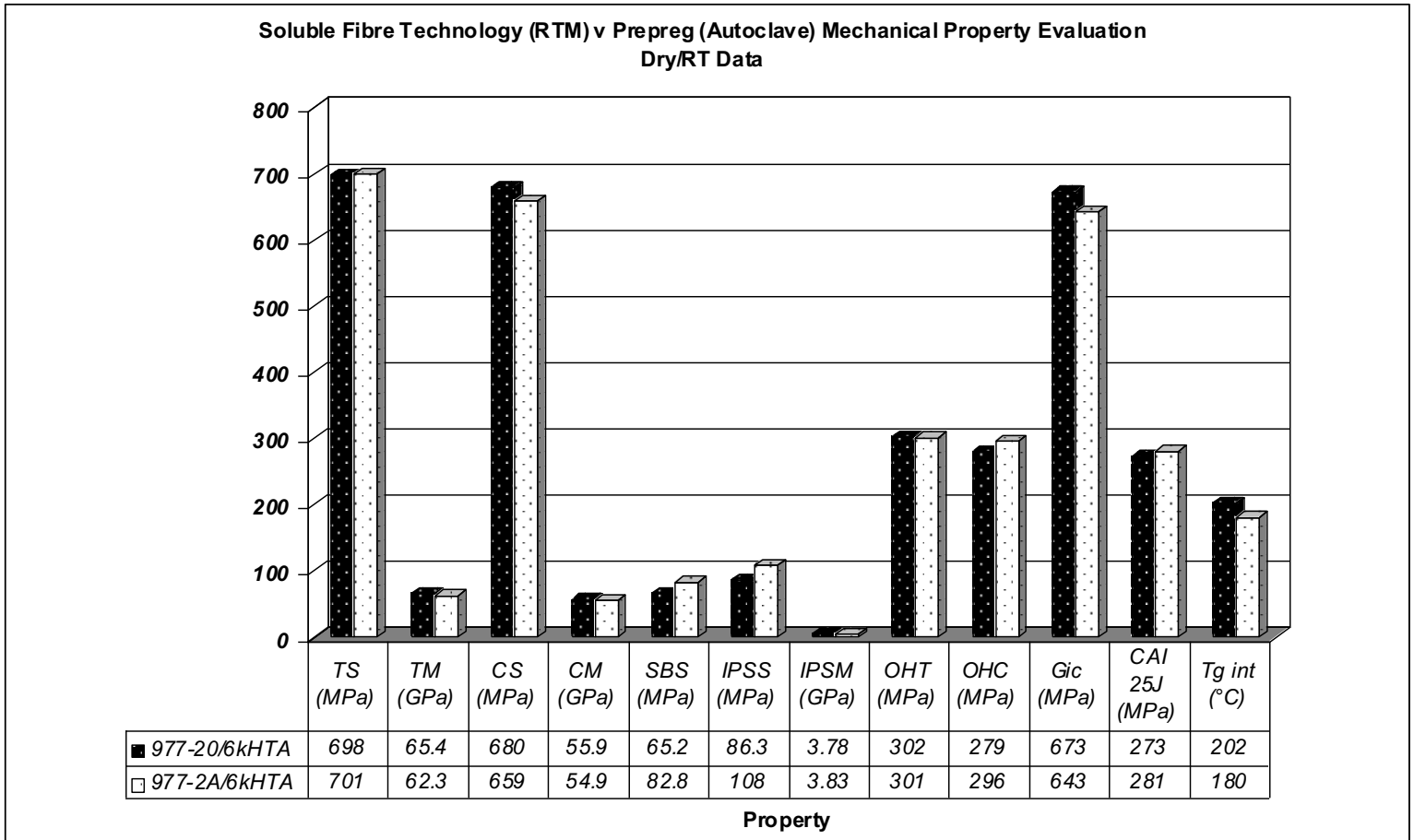






PRIFORM: Interwoven Soluble Fiber

977-20 PRIFORM equivalent to 977-2 properties



	TS (MPa)	TM (GPa)	CS (MPa)	CM (GPa)	SBS (MPa)	IPSS (MPa)	IPSM (GPa)	OHT (MPa)	OHC (MPa)	Gic (MPa)	CAI 25J (MPa)	Tg int (°C)
977-20/6kHTA	698	65.4	680	55.9	65.2	86.3	3.78	302	279	673	273	202
977-2A/6kHTA	701	62.3	659	54.9	82.8	108	3.83	301	296	643	281	180

Equivalent Properties to Prepreg Resins

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PRIFORM: Interwoven Soluble Fiber

Successful Applications

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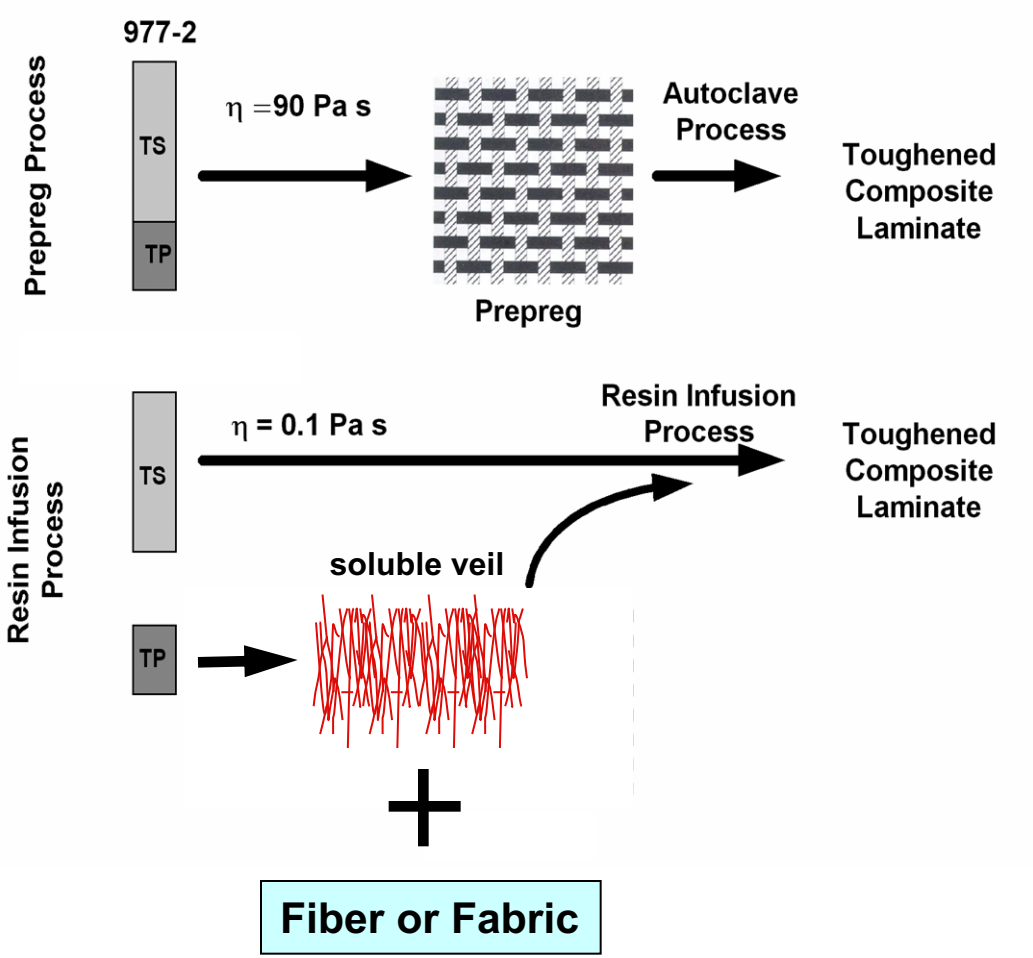
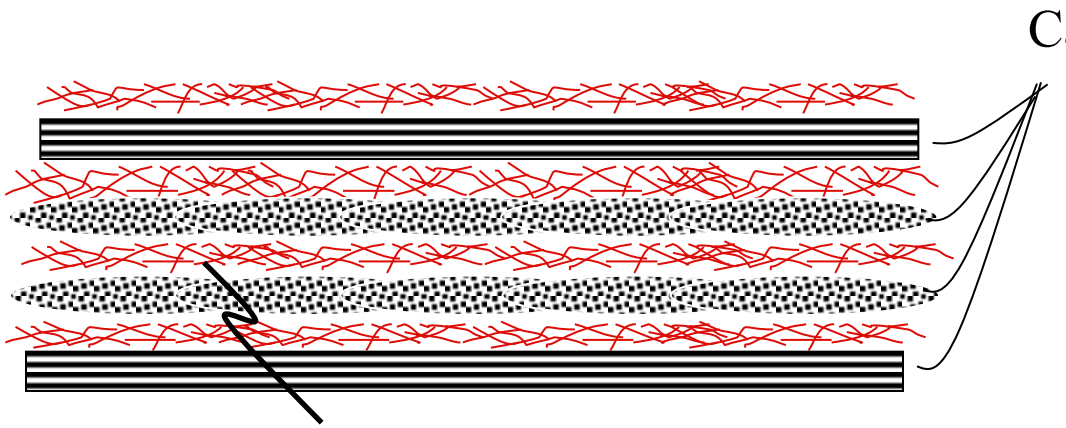
PRIFORM Soluble Veil

Soluble Veil Technology



PRIFORM Soluble Veil

Soluble Veil Technology



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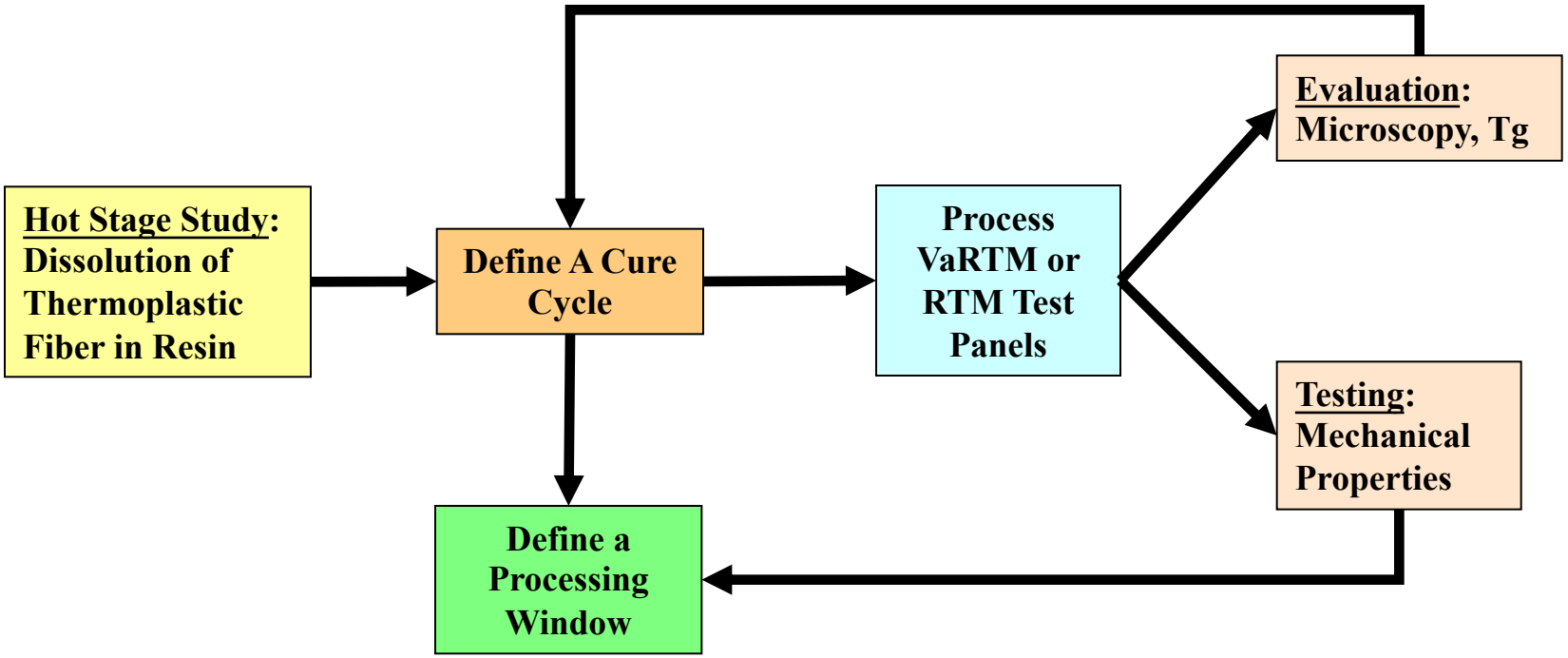
PRIFORM Soluble Veil

Advantages

- Design Flexibility
  - Localized toughening (surface, notch areas, ..)
  - Tailorability of toughener percentage
- Part Manufacturing
  - Self heat stabilizing of dry preforms
  - Self binding of preform layup
    - No need for tackifiers
  - No need for a dissolution hold step in the curing cycle
    - Same cure cycle as prepreg
- Reduced processing costs & labor
  - Eliminates need for fiber spinning and weaving into preform reinforcements.

PRIFORM Soluble Veil

Iterative Development Approach to Achieve Optimal Curing Cycle



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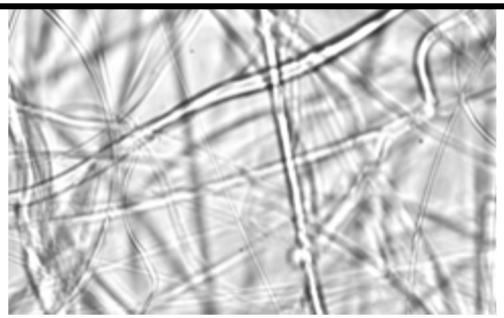
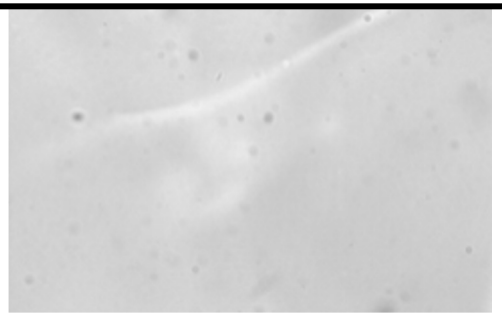
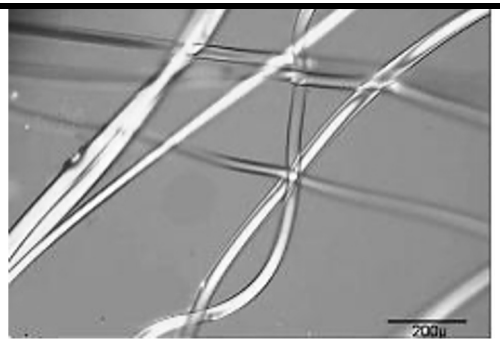
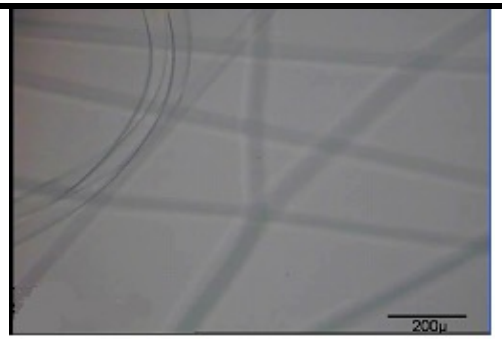
PRIFORM Soluble Veil : Dissolution

Dissolution microscopy, veils in epoxy

	End of 1 hour hold at 75° C	End of ramp from 75° C to 175° C
Soluble Veil		 **Full dissolution**
Aerospace Polyamide Veil		 **Barely melts**

PRIFORM Soluble Veil : Dissolution

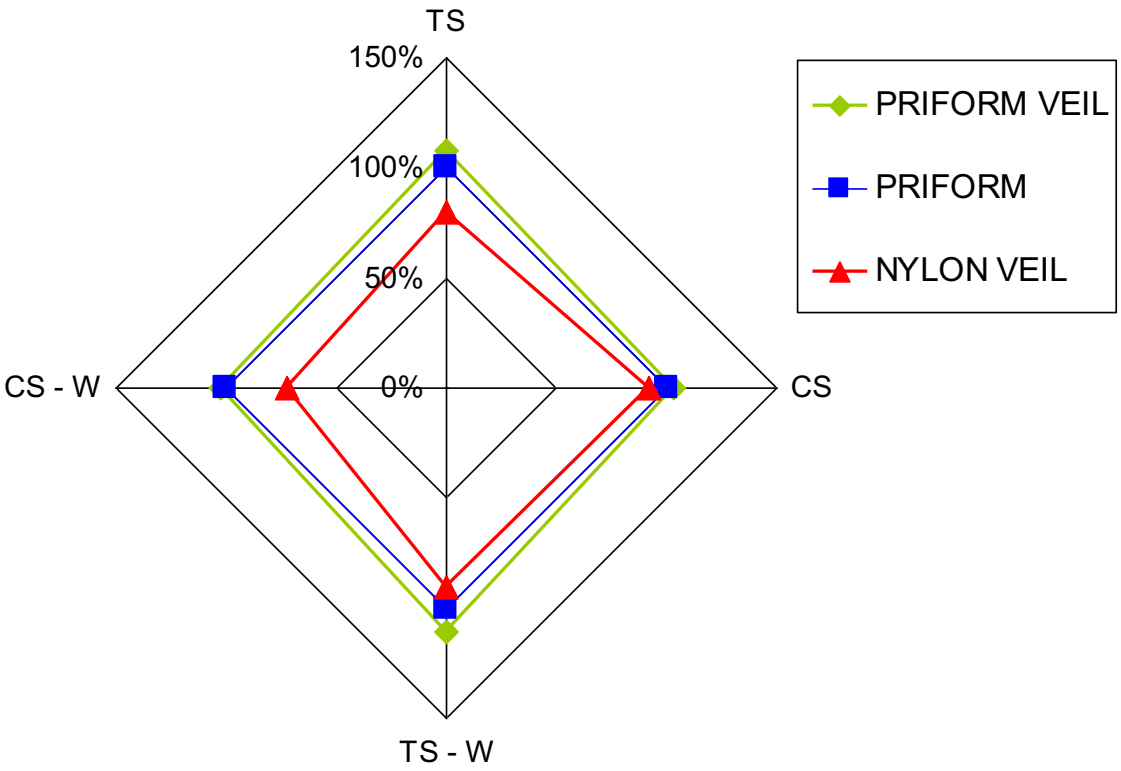
- Other veils used in the composite industry offer preforming and some degree of toughening, however:
  - Nylon veils do not dissolve in the matrix, but rather slightly melt
  - The matrix is a distinct and coarse two phase system susceptible to the shortcomings of each phase:
    - microcracking of the epoxy phase
    - solvent resistance of the thermoplastic phase.

- Soluble veil is a resin toughening veil that completely dissolves in epoxy resin delivering:
  - Low viscosity injection
  - Preforming
  - Toughness
  - FST
  - High temperature performance

Mechanical Property Evaluation

Key Mechanical properties have been tested in both Dry Room Temperature and Hot Wet condition (equilibrium + 120° C test) on:

- Standard PRIFORM 5HS 370gsm
- 5HS 370 gsm + Soluble Veil
- 5HS 370 gsm + Aerospace Nylon Veil



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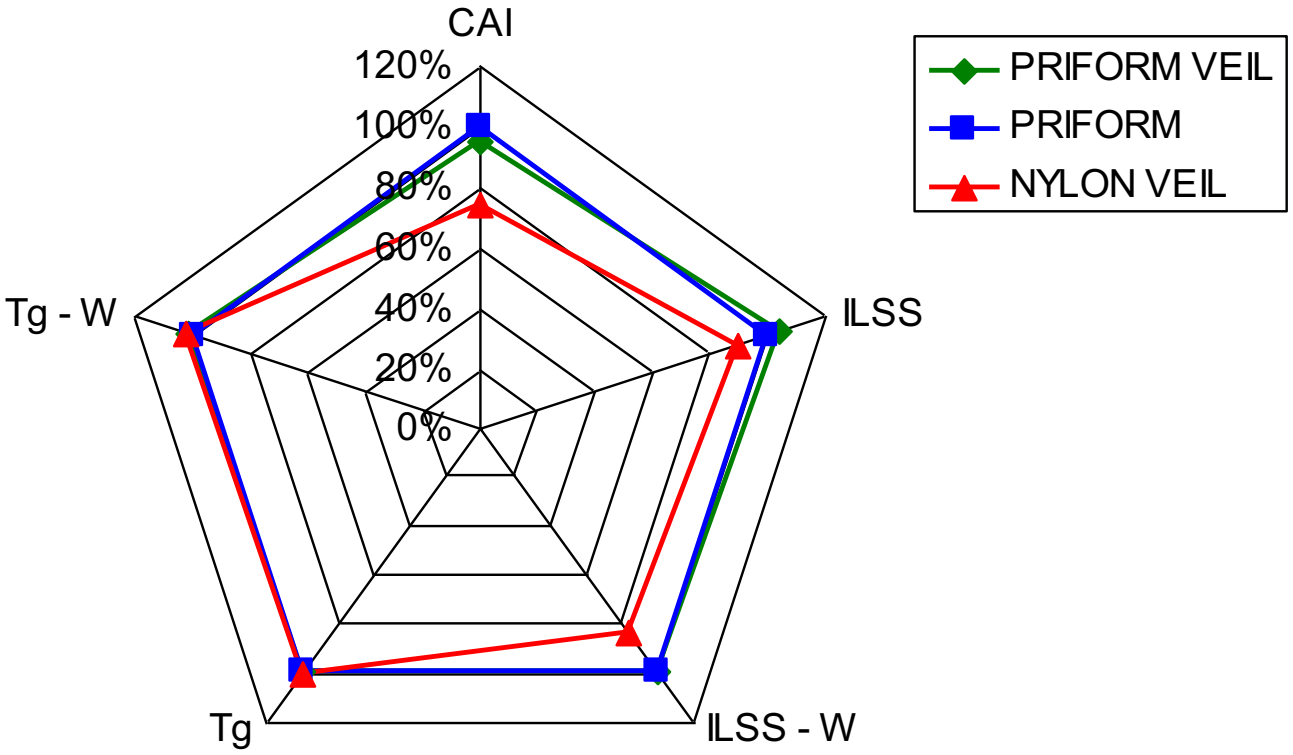
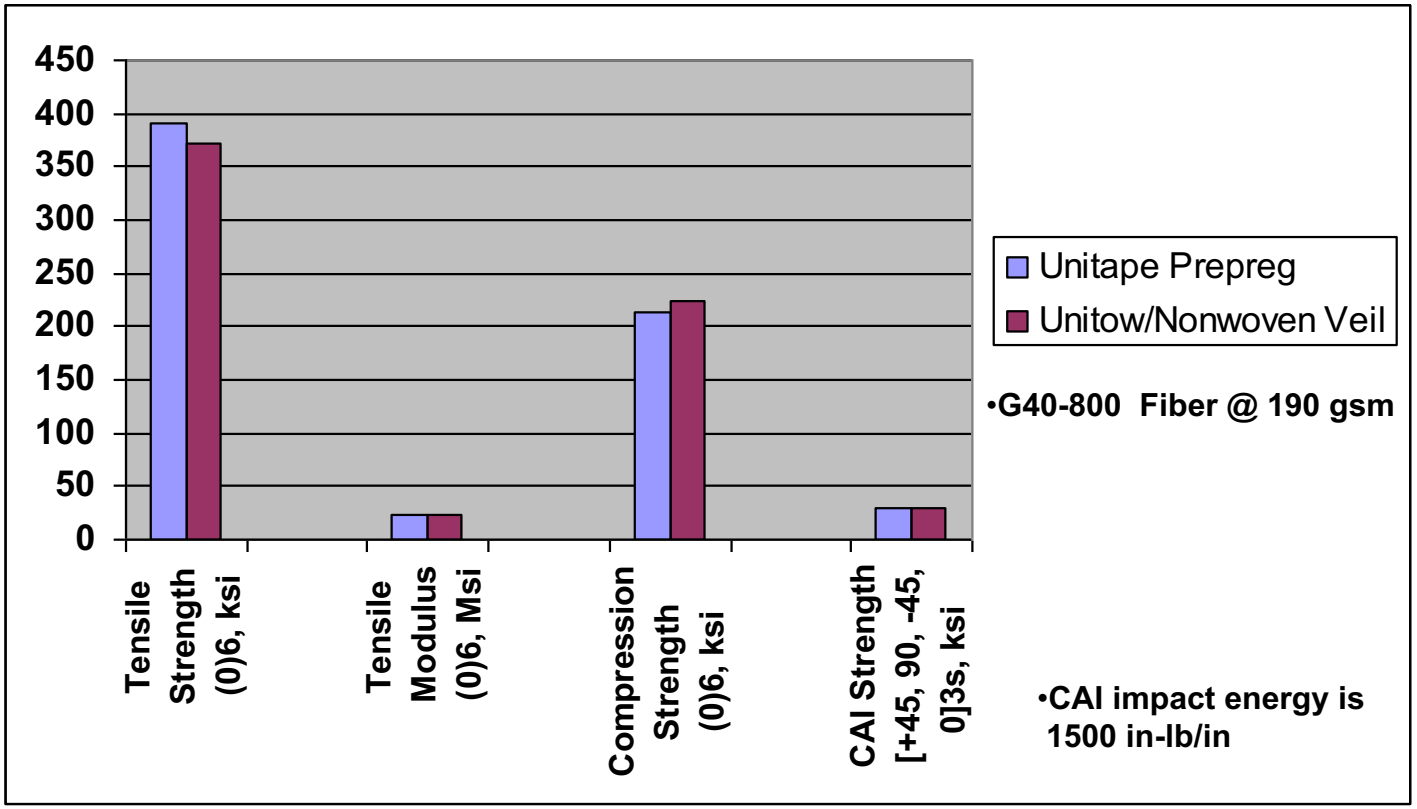
Mechanical Property Evaluation



- Strength, shear and impact properties are enhanced compared to Nylon veils
- Equivalent performance to Interwoven soluble fiber PRIFORM baseline is demonstrated

Mechanical Property Evaluation

Unitow + Soluble Veil/ 977-20 Vs. 977-2 Prepreg UD Tape
Initial Results - RT-Dry



Properties of Unitow + Soluble veil and UD tape are equivalent
Further testing is in progress….

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Soluble Veil Technology: Conclusions

- Soluble Veil Technology offers:
  - Unique toughness enhancement for a RI system
  - Low cost RI manufacturing processes
  - Superior performance to polyamide veils
  - Same properties as interwoven soluble fiber technology
  - Bonding to various forms of dry carbon
  - Heat stabilization and preforming at moderate temperatures
  - Wide process window compatible with RTM and VARTM