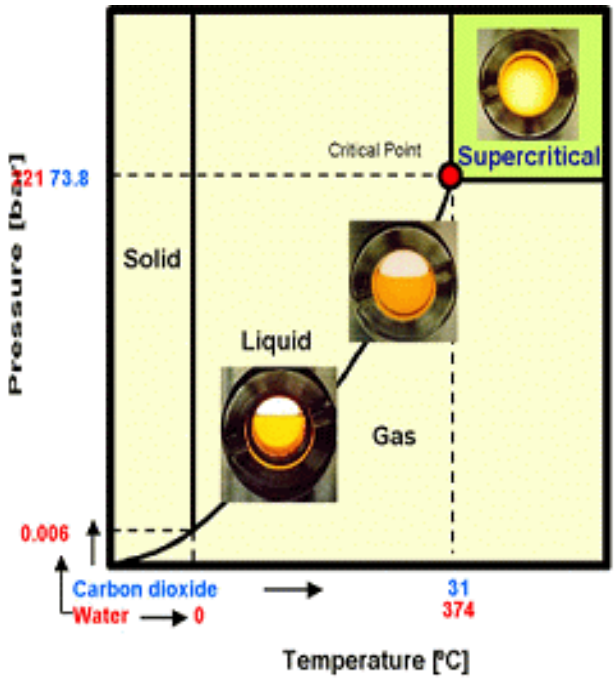
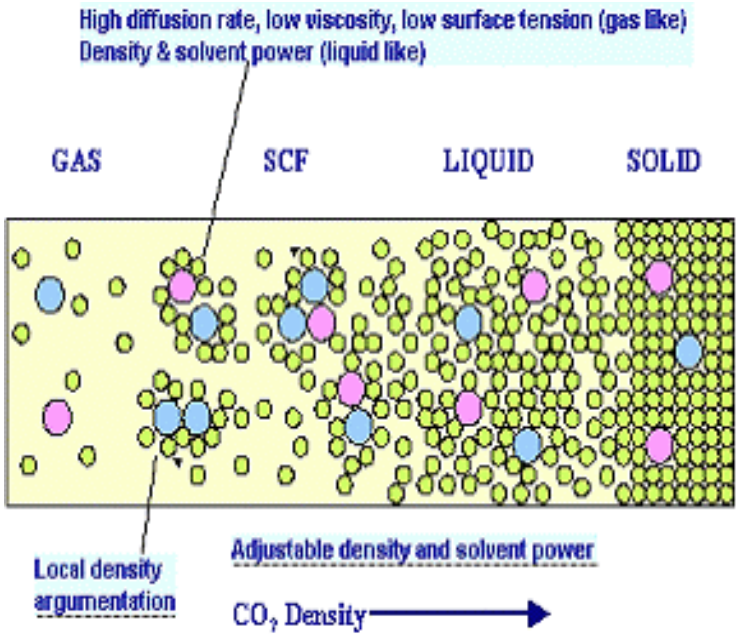
Development of A New Processing System with Power Ultrasound and scCO2 for Polymer Blends

Dong Chul Shim, Jae Ho Han, Kyung Il Kim, Young Joon Ahn, Jae Wook Lee
Applied rheology center, Department of chemical engineering, Sogang Univ.
1 Shinsu-dong, Mapo-ku, Seoul, 121-742, Korea

Introduction

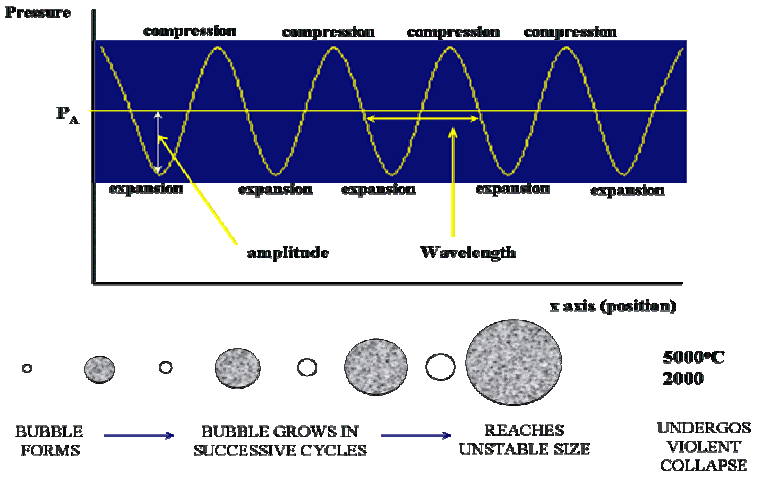
Supercritical fluid define & properties

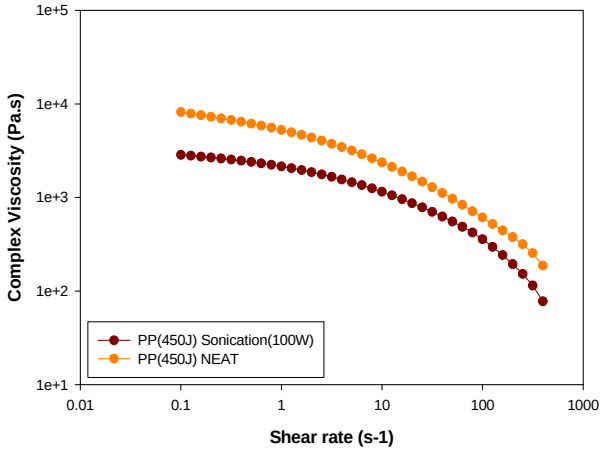


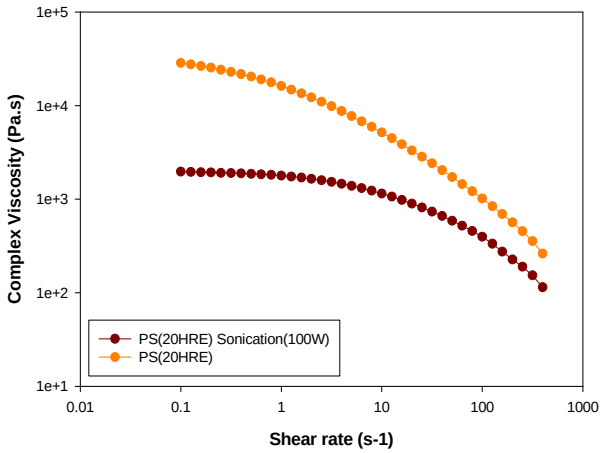


Introduction

Degredation of polymer under sonication





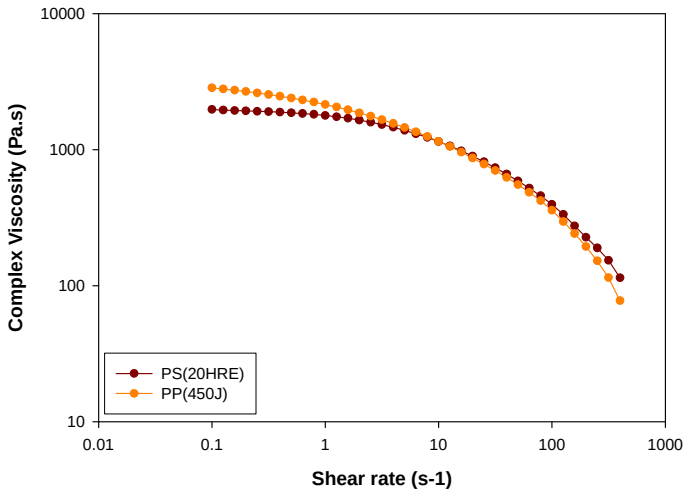


Experimental

Materials

Polymer

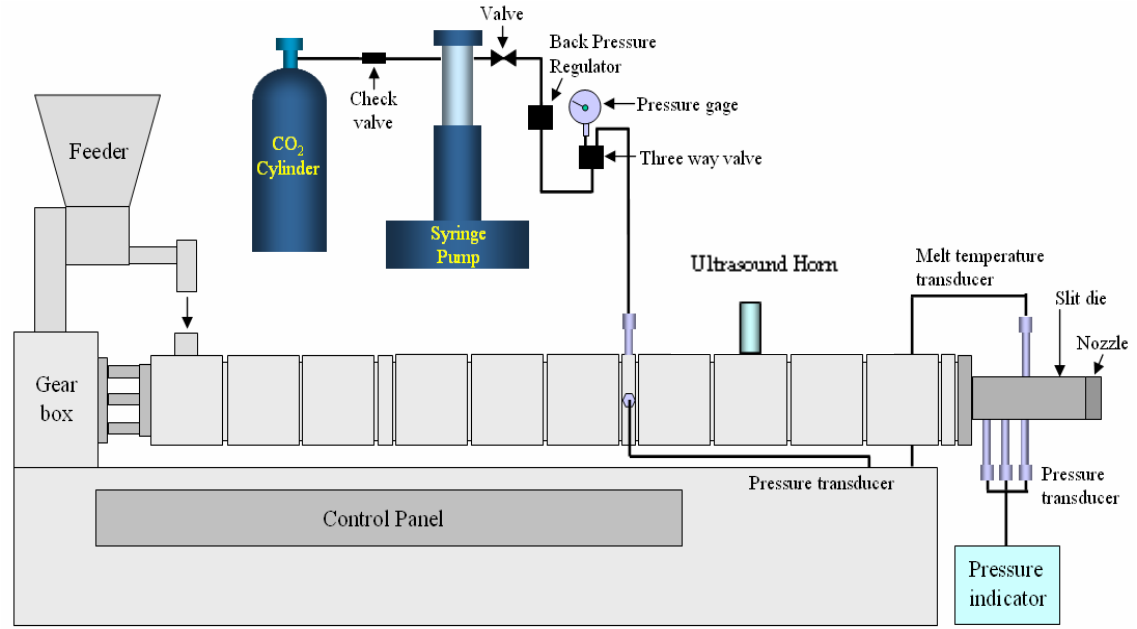
- *Polypropylene (HP450J, Polymirae Co.)*
  - *Density : 0.95 g/cm3*
  - *MFI: 3.24 g/10min*
- *Polystyrene (20HR(E), LG CHEM)*
  - *Density : 1.05 g/cm3*
  - *MFI: 6 g/10min*



Carbon dioxide

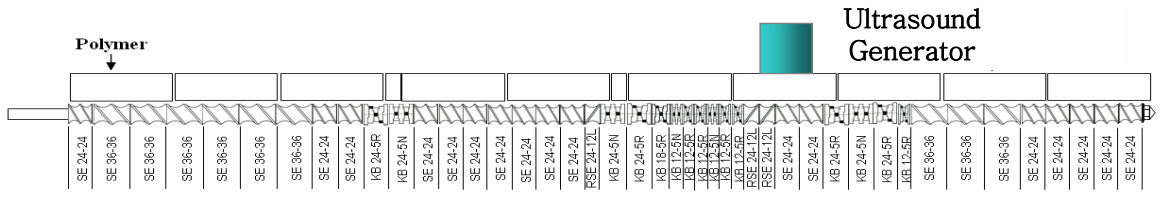
- *degree of purity: 99.99 %*

Manufacturing Process of using scCO2 & Ultrasound



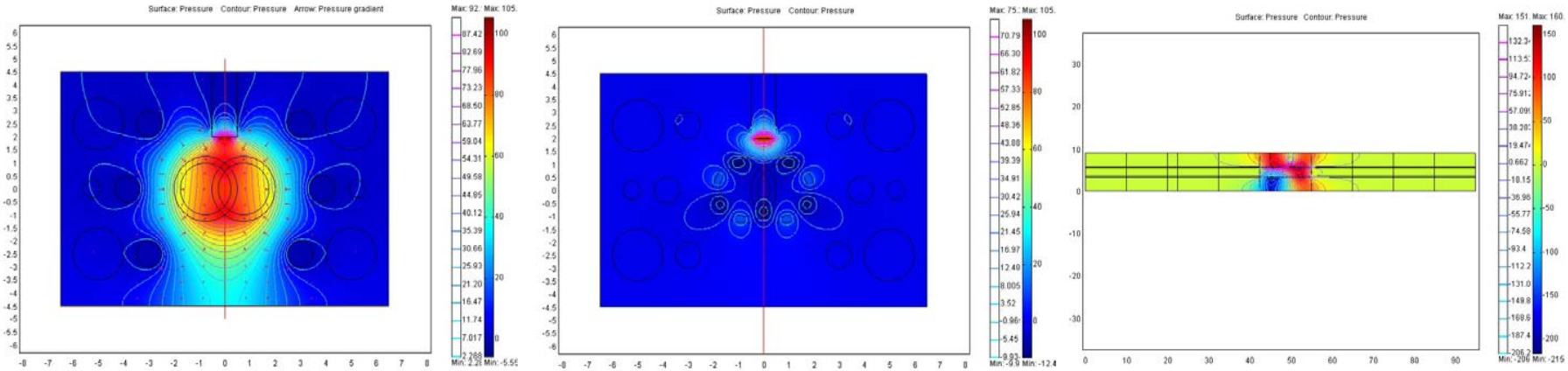
- ***Screw diameter: 25 mm***
- ***L/D: 41***
- ***Segmented type screw***

Ultrasonic Device : MPI-MASTERSONIC® (MSG-IX)—www.mpi-ultrasonics.com & www.mastersonics.com

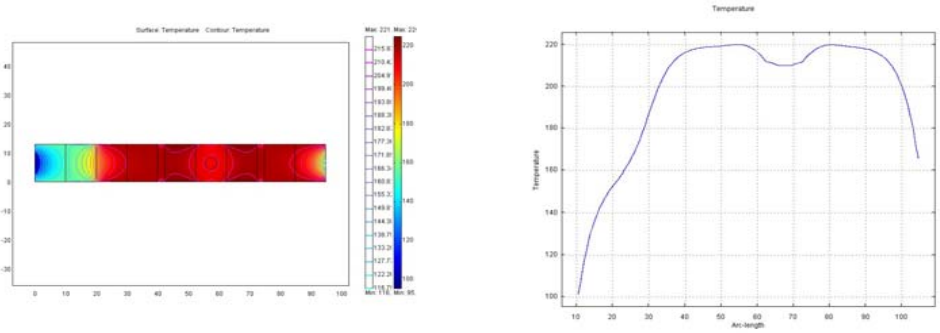


Acoustic & Temperature Simulation of Extruder Barrel

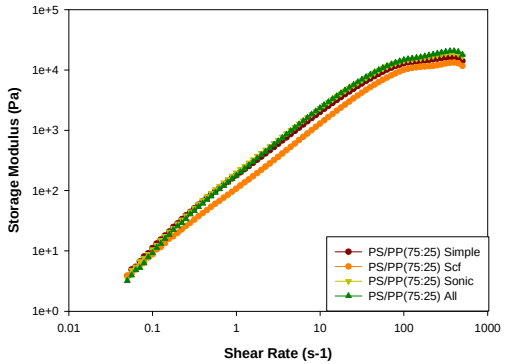
Acoustic Simulation



Barrel Temperature Simulation



Method of Interfacial Tension Calculation



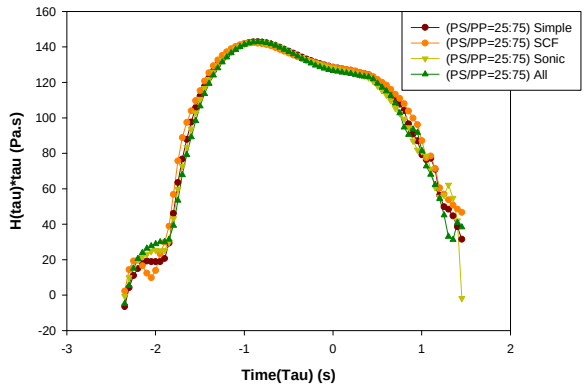
Ferry and Tschoegl model

$$H(\tau)=G\left[\frac{d\log G}{d\log\omega}-\frac{1}{2}\left(\frac{d\log G}{d\log\omega}\right)^2-\frac{1}{4.606}\frac{d^2\log G}{d(\log\omega)^2}\right]_{1/\omega=\tau/\sqrt{2}}$$

Choi and Schowalter model

$$\tau_0=\frac{\eta_m R}{\alpha}\frac{(19k+16)(2k+3)}{40(k+1)}$$

$$\tau_1=\tau_0\left[1+\Phi\frac{5(19k+16)}{4(k+1)(2k+3)}\right]$$



Method of Viscosity Calculation

Working equations for slit rheometer

- **Viscosity**

$$\eta = \tau_w / \dot{\gamma}_w$$

- **Wall shear stress**

$$\tau_w = \frac{H}{2(1+H/W)}\frac{dP}{dx}$$

- **Apparent shear rate**

$$\dot{\gamma}_{ap} = 6Q/WH^2$$

- **Wall shear rate**

$$\dot{\gamma}_w = \frac{\dot{\gamma}_{app}}{3}\left(2+\frac{d\ln\dot{\gamma}_{app}}{d\ln\tau_w}\right)$$

- **Volumetric flow rate**

$$Q = \dot{m}/\rho$$

P: pressure

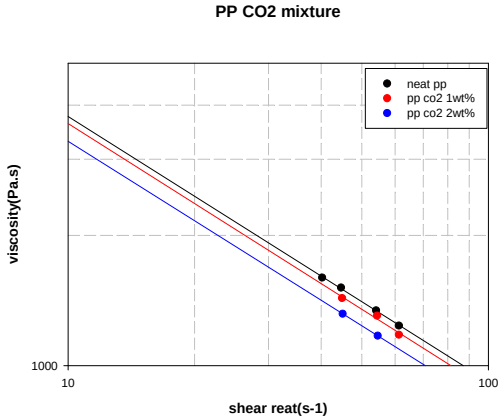
x: length

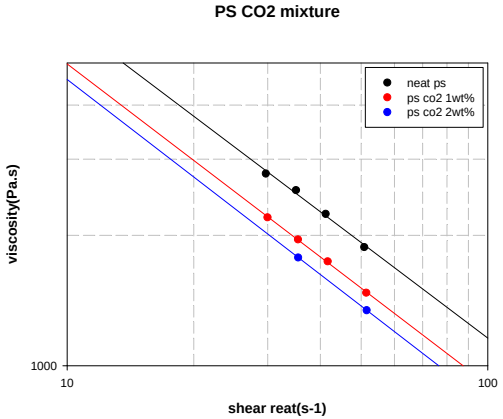
H: height

W: width

$\dot{m}$

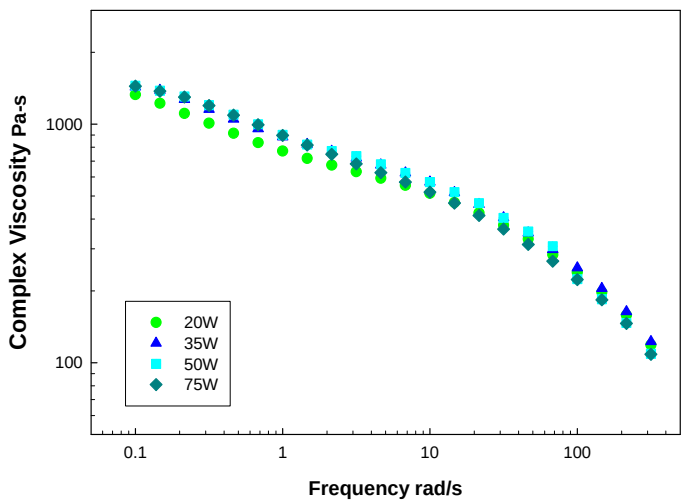
ρ



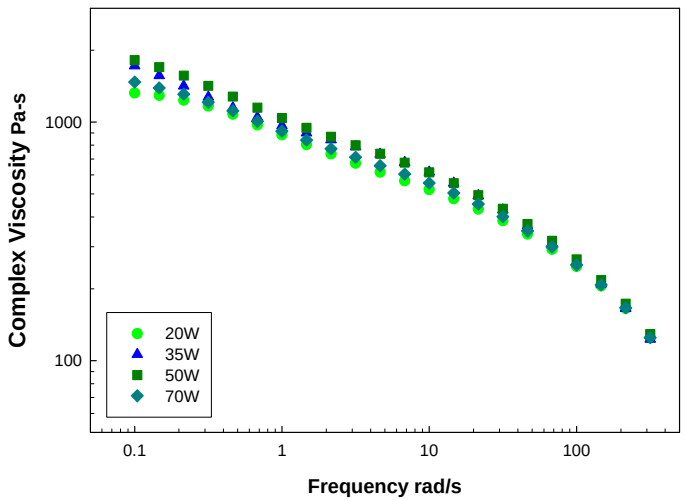


Effect of Sonication Power on Polymer Blend

Sonicated Mixing

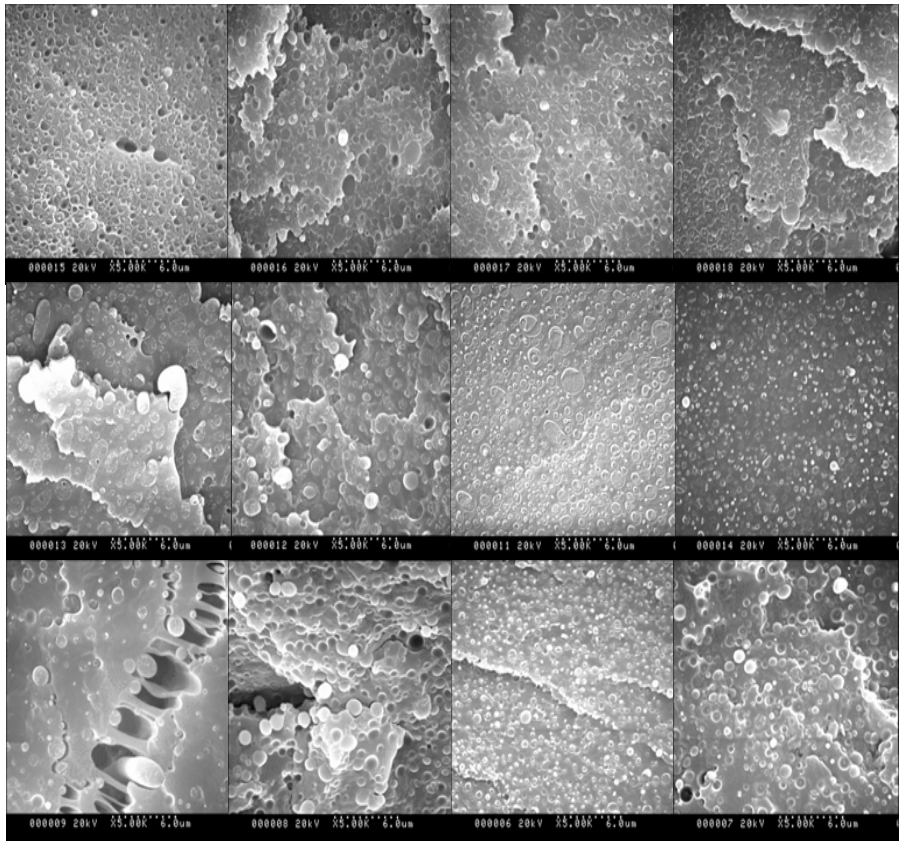


SCF & Sonicated Mixing



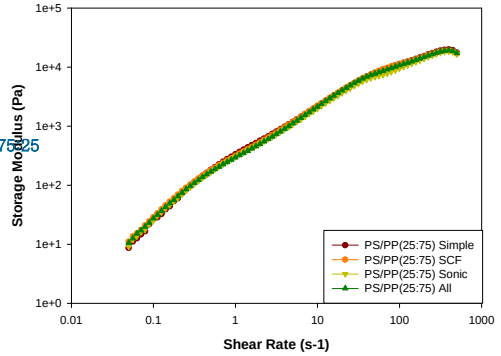
Results and discussion

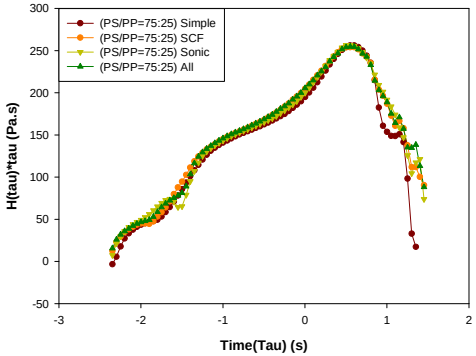
- **SEM images of PP/PS Blends:(www.mpi-ultrasonics.com & www.mastersonics.com)**



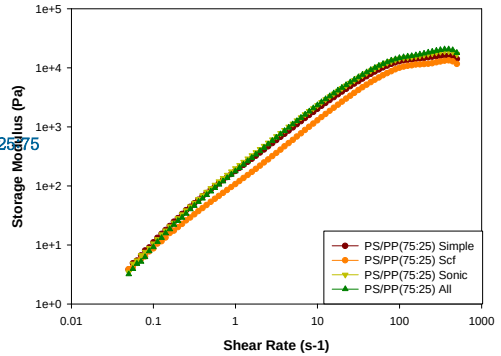
Interfacial Tension Estimation

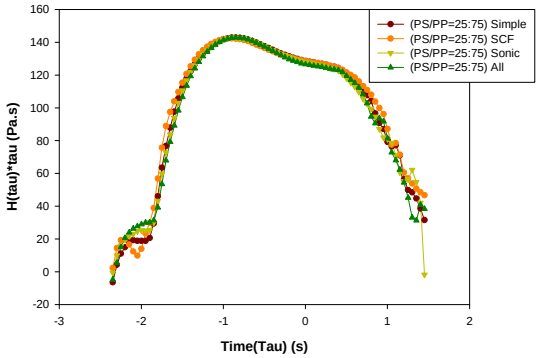
PS/PP=75/25

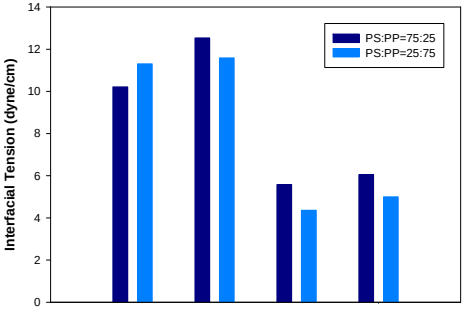




PS/PP=25/75

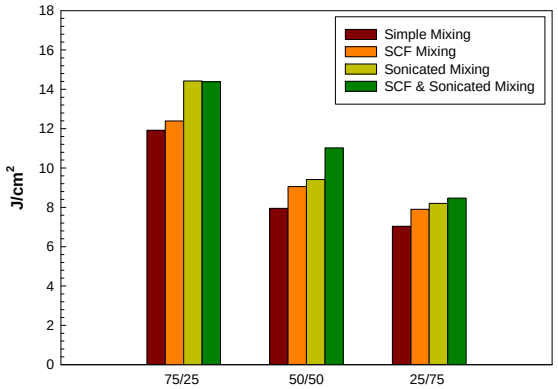




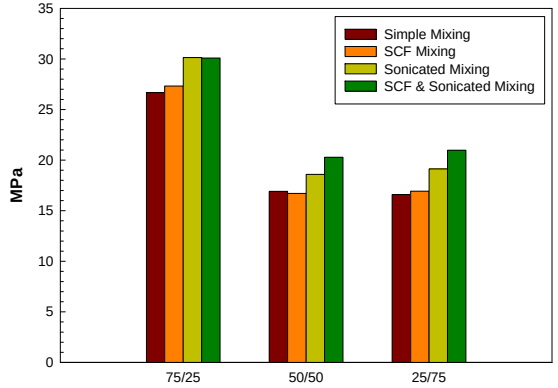


Mechanical properties

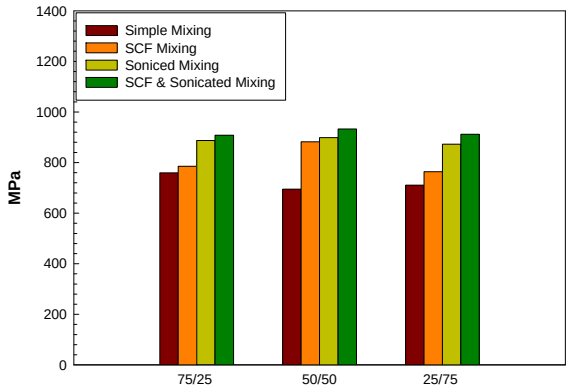
Impact Strangth



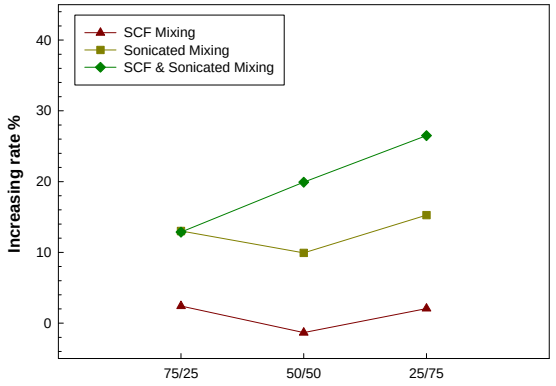
Tensile Strangth



Young's Modulus

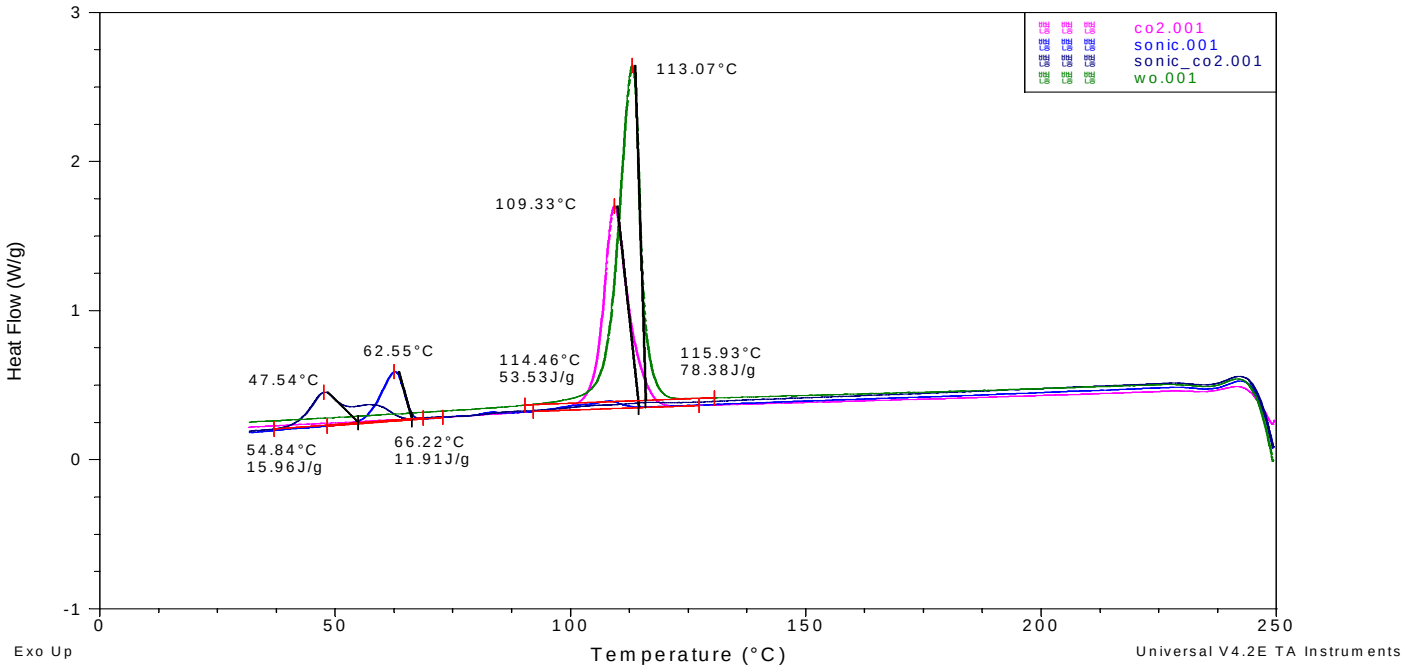


Tensile Strength



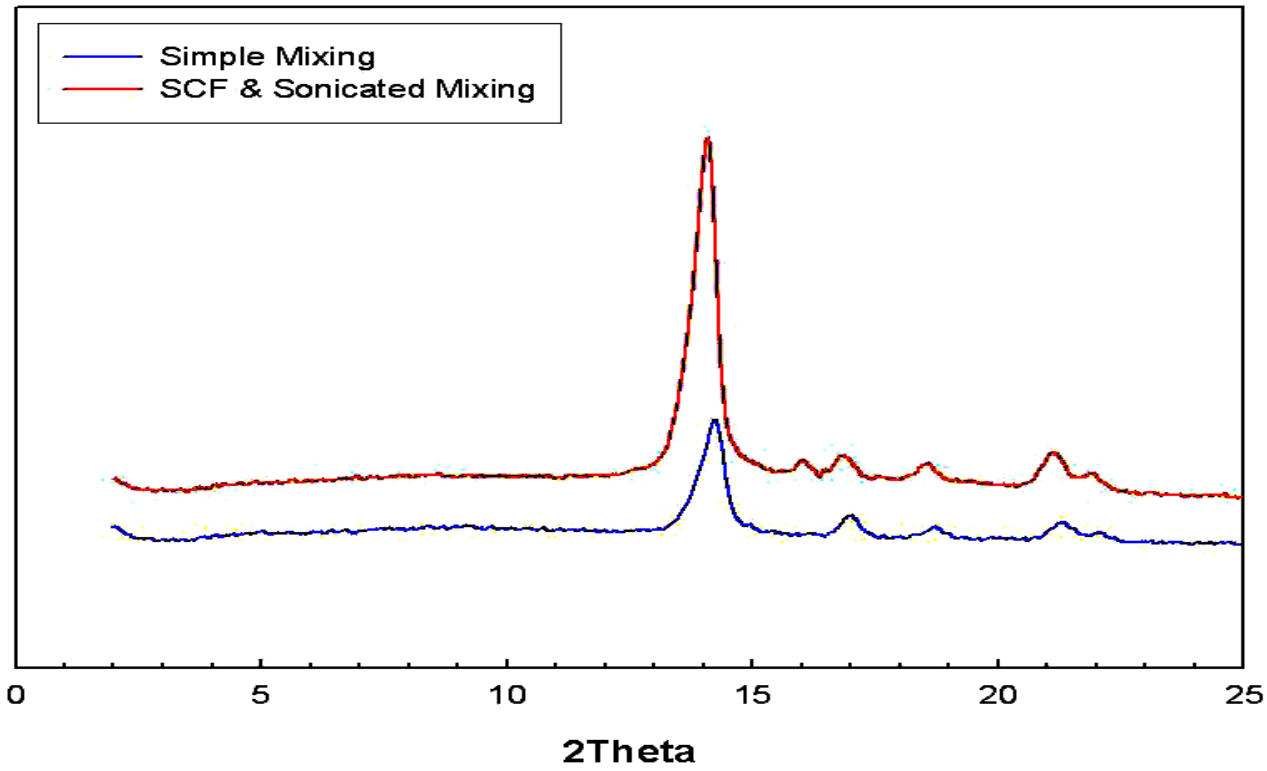
Results and discussion

- **Tc curve of PP/PS Blend using DSC**



Results and discussion

- **WAXD patterns of PP/PS =75/25 blend**



Conclusions

- By using high intensity ultrasound (www.mpi-ultrasonics.com), it was possible to change rheological properties of various thermoplastics during melt mixing.
- Compatibilty was increased in immiscible polymer blends without any compatibilizers: mutual coupling between different radical PP and PS
- Supercritical CO2 exhibited synergistic effects with ultrasound on the morphology and properties of the polymer blends.