Industrial application of rheology

Introduction

- 유변학: 물질의 유동과 변형에 관한 학문
- 재료의 미세한 구조차이가 유변물성을 통하여 증폭되어 발현
- 품질관리, trouble shooting, 제품설계 등 다양한 용도로 사용

Industrial Applications of Rheology

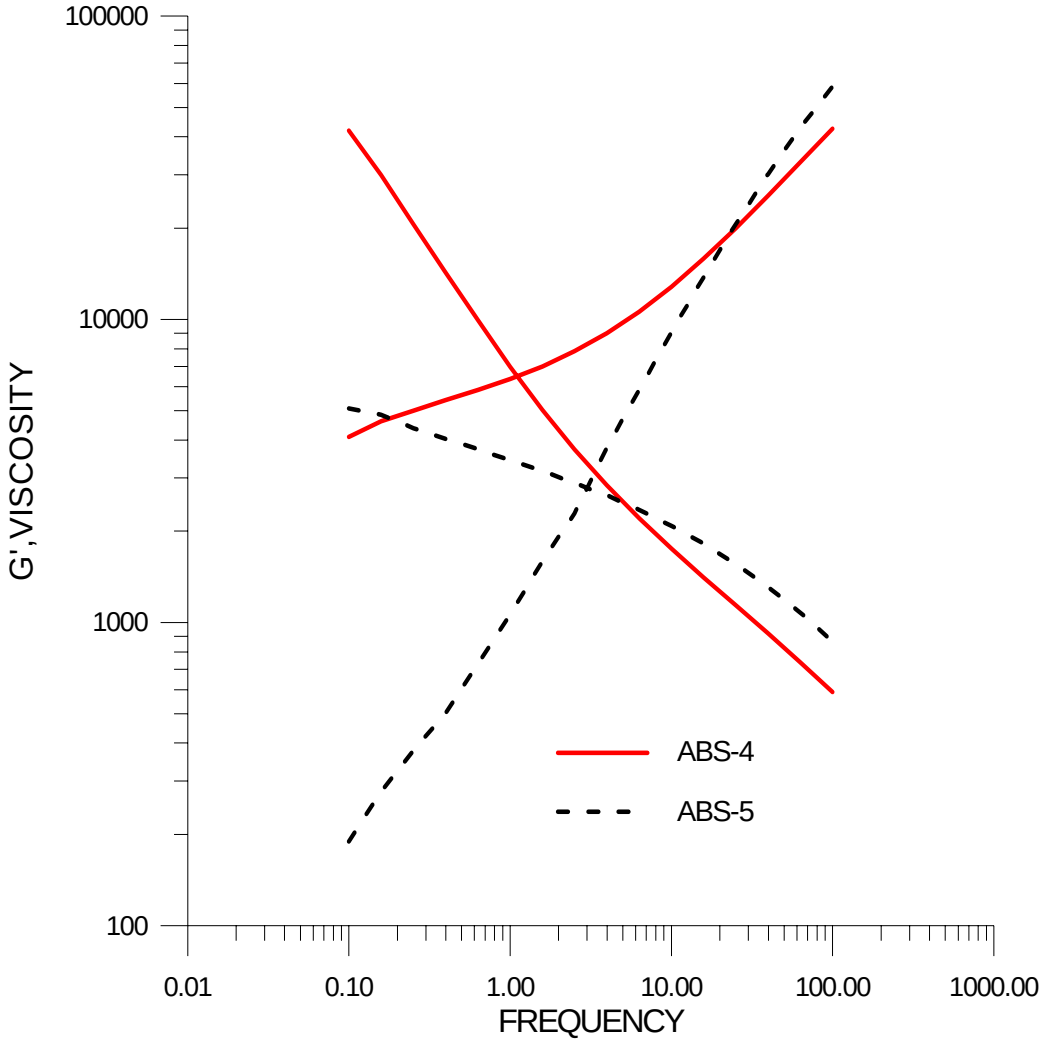
유변물성 측정의 유용성

- ABS (Acrylonitrile-Butadiene-Styrene) 수지의 예
- 올레핀 수지의 예
- 식품 유변학에서의 예
- 나노복합체 (clay nano composite)의 예
- 생체고분자 (biopolymer)의 예

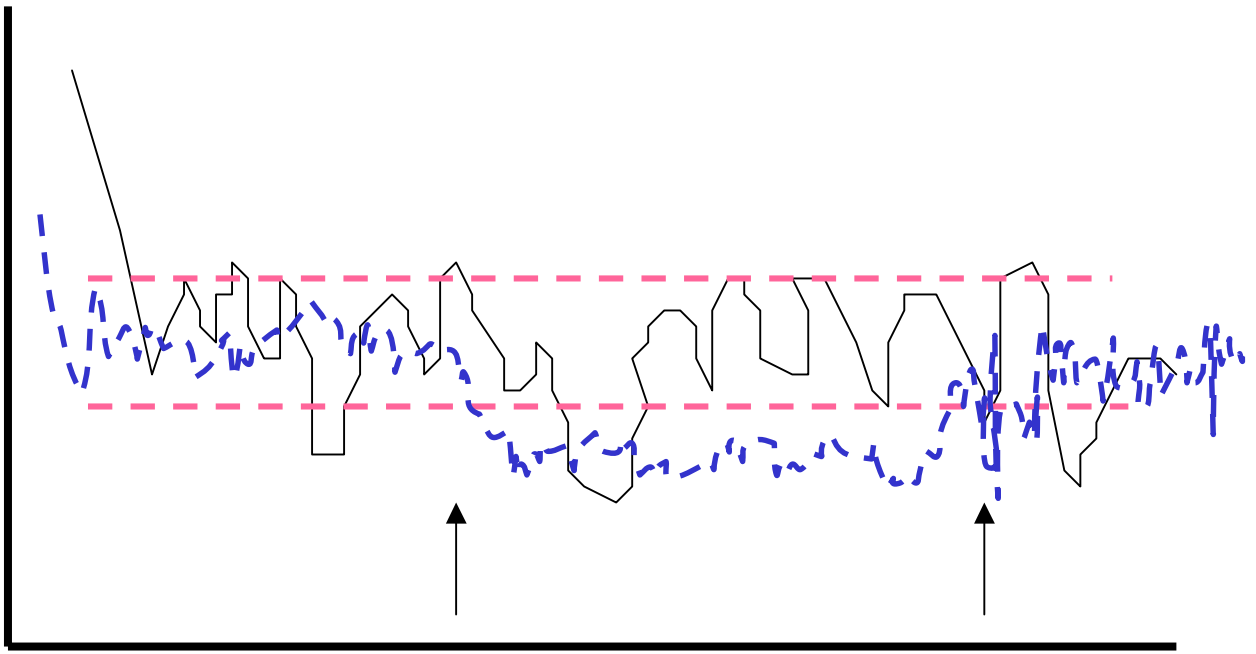
ABS (Acrylonitrile-Butadiene-Styrene)

	Particle size	Gel content	Graft ratio	Impact strength	Hard-ness	Tensile strength	Flexural strength	VST	gloss
ABS-4	3075	86	42	26.7	96.4	402	582	93.7	103.9
ABS-5	3100	82	69	24.1	95.3	393	567	95.1	101.7

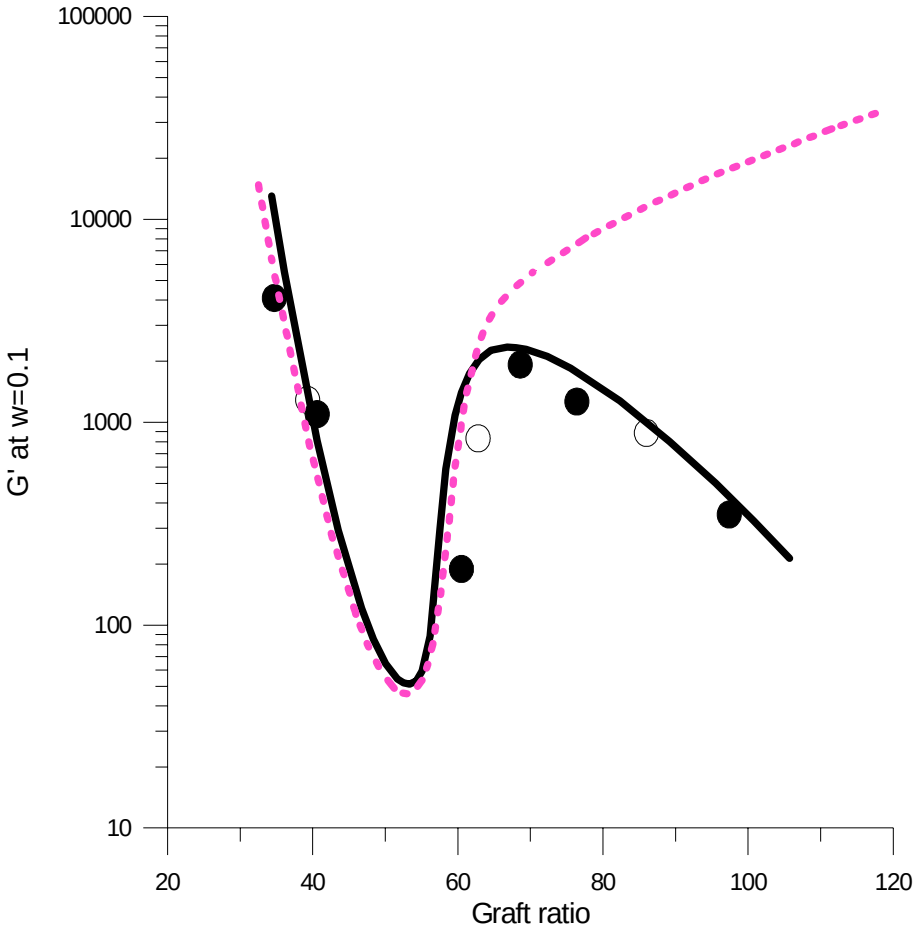
G’ and η* of ABS


100000
10000
1000
100
G',VISCOSITY
0.01
0.10
1.00
10.00
100.00
1000.00
FREQUENCY
ABS-4
ABS-5

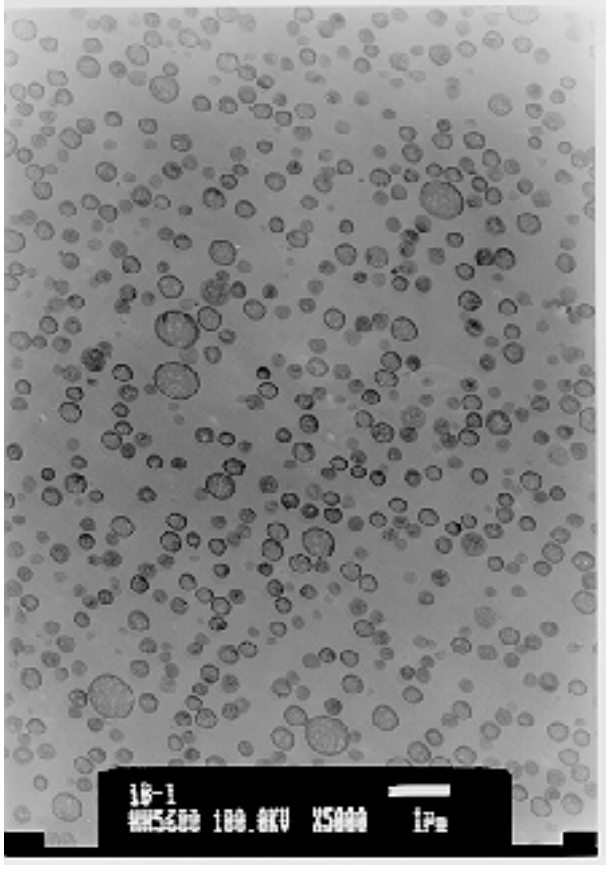
관리도(G')

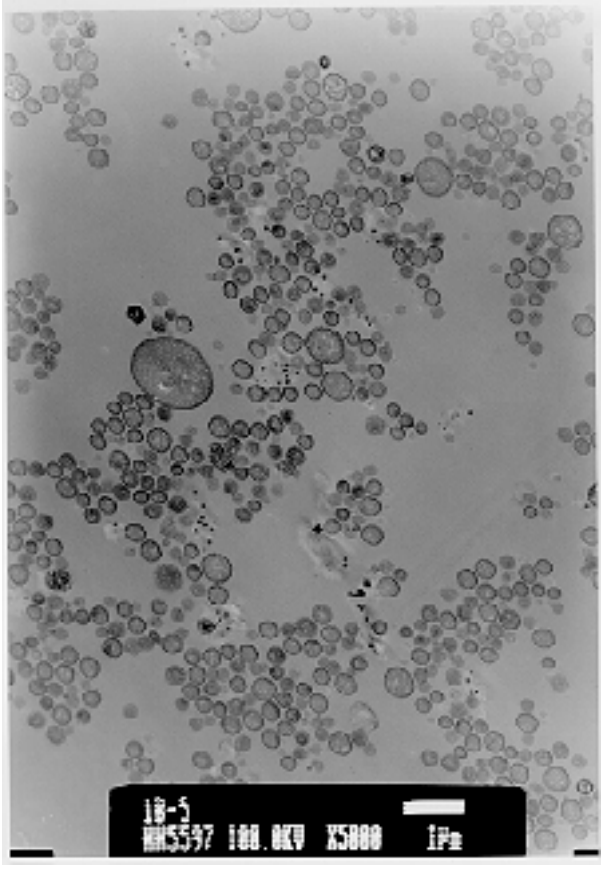


G’ vs. graft ratio

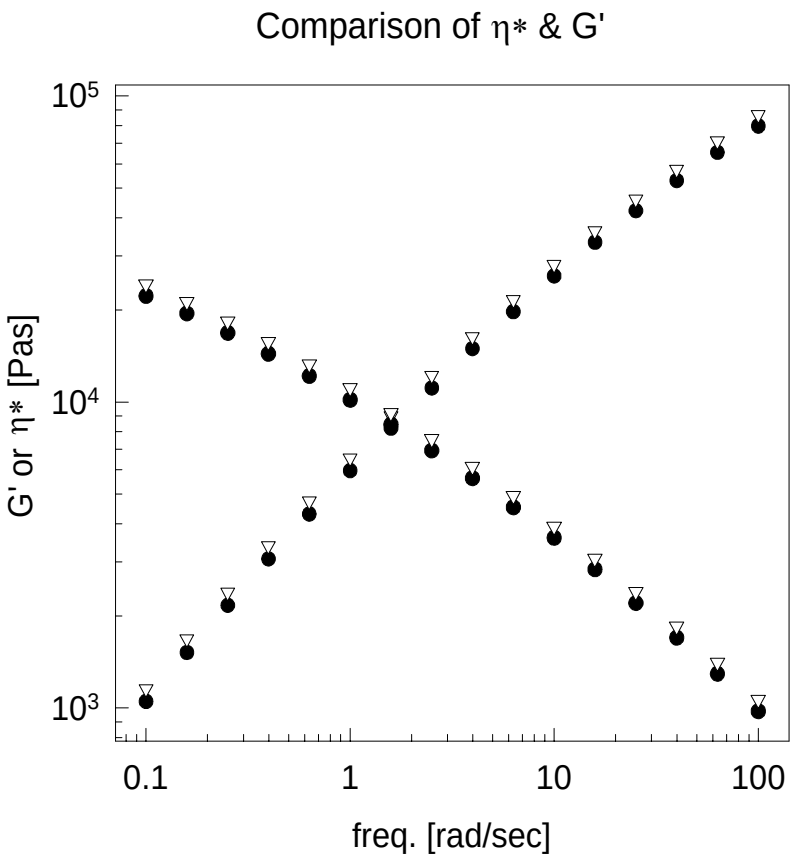


Particle agglomeration



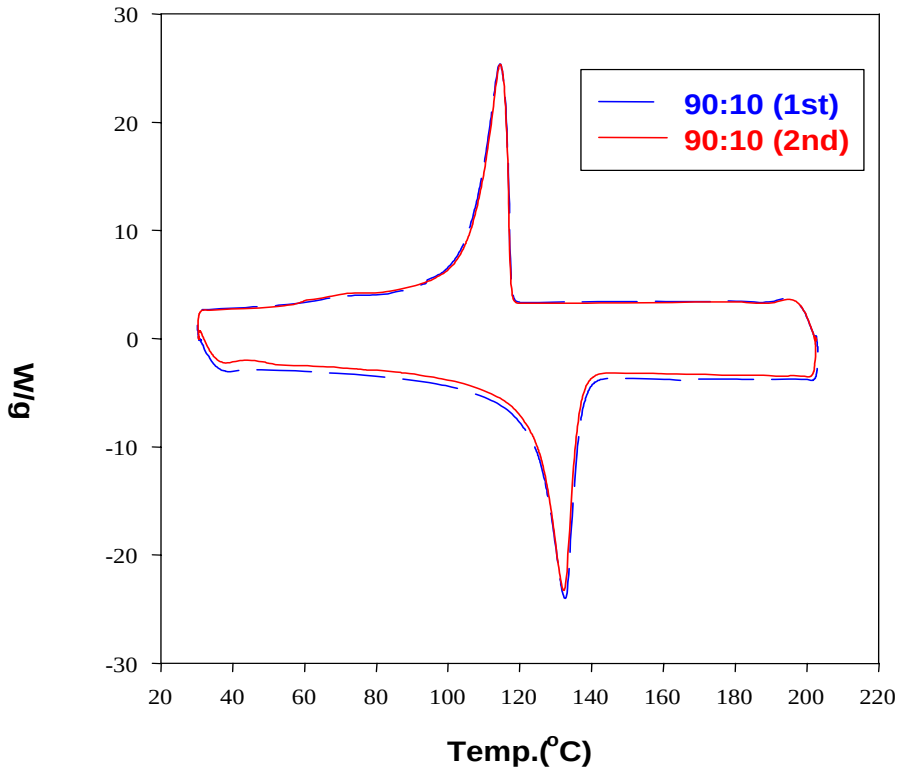


HDPE/PS blends

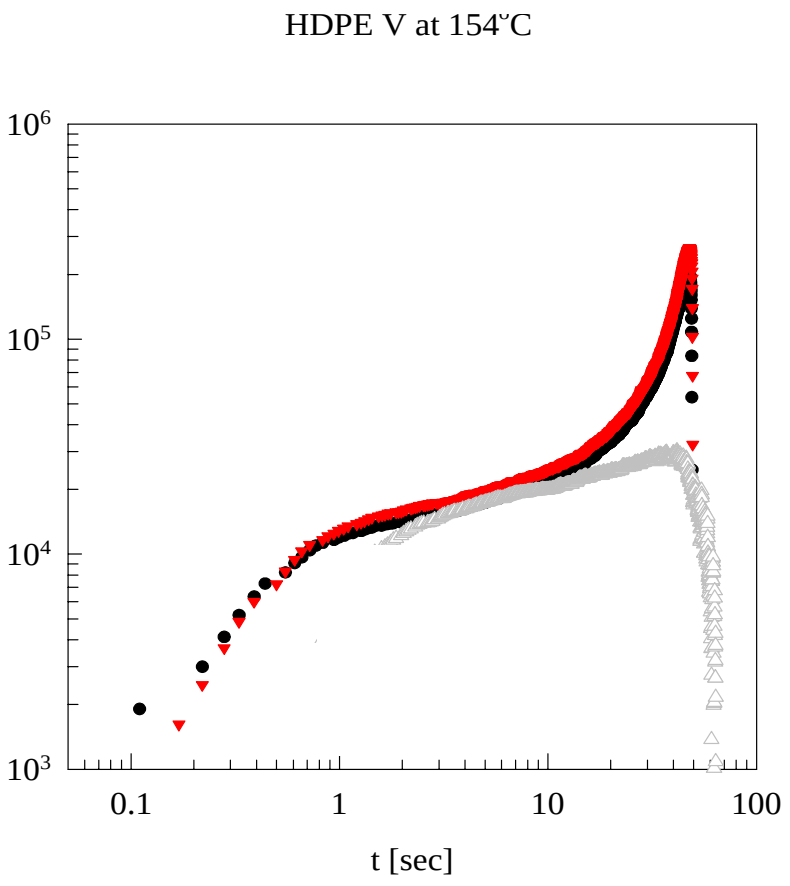


HDPE/PS blends

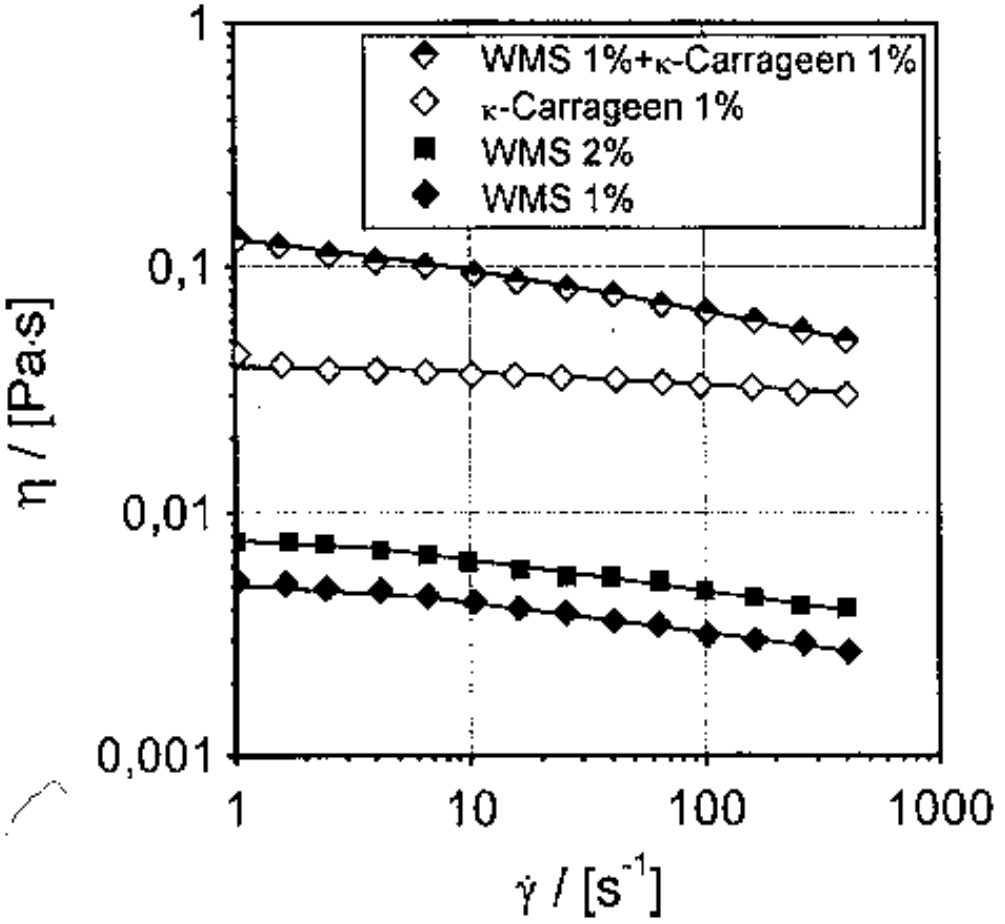
DSC (10^{o}C/min)



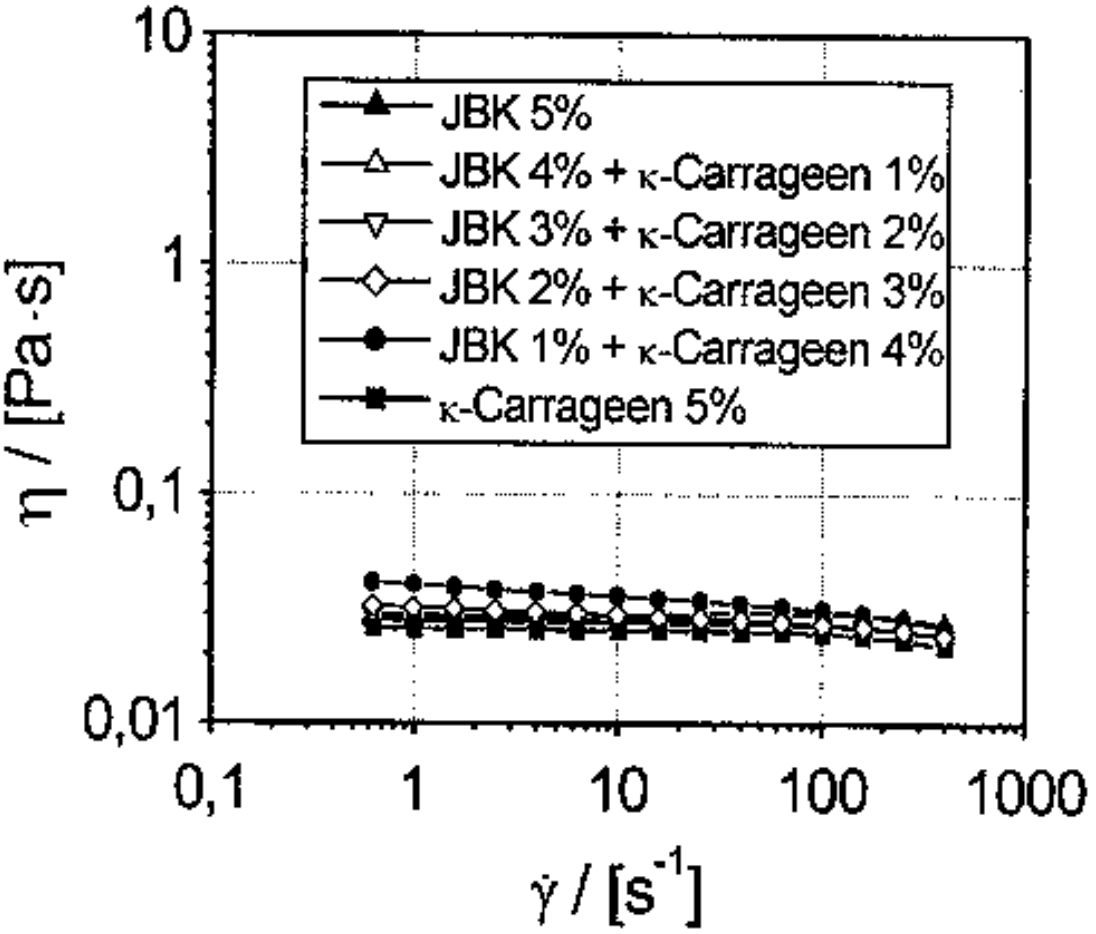
HDPE/PS blends

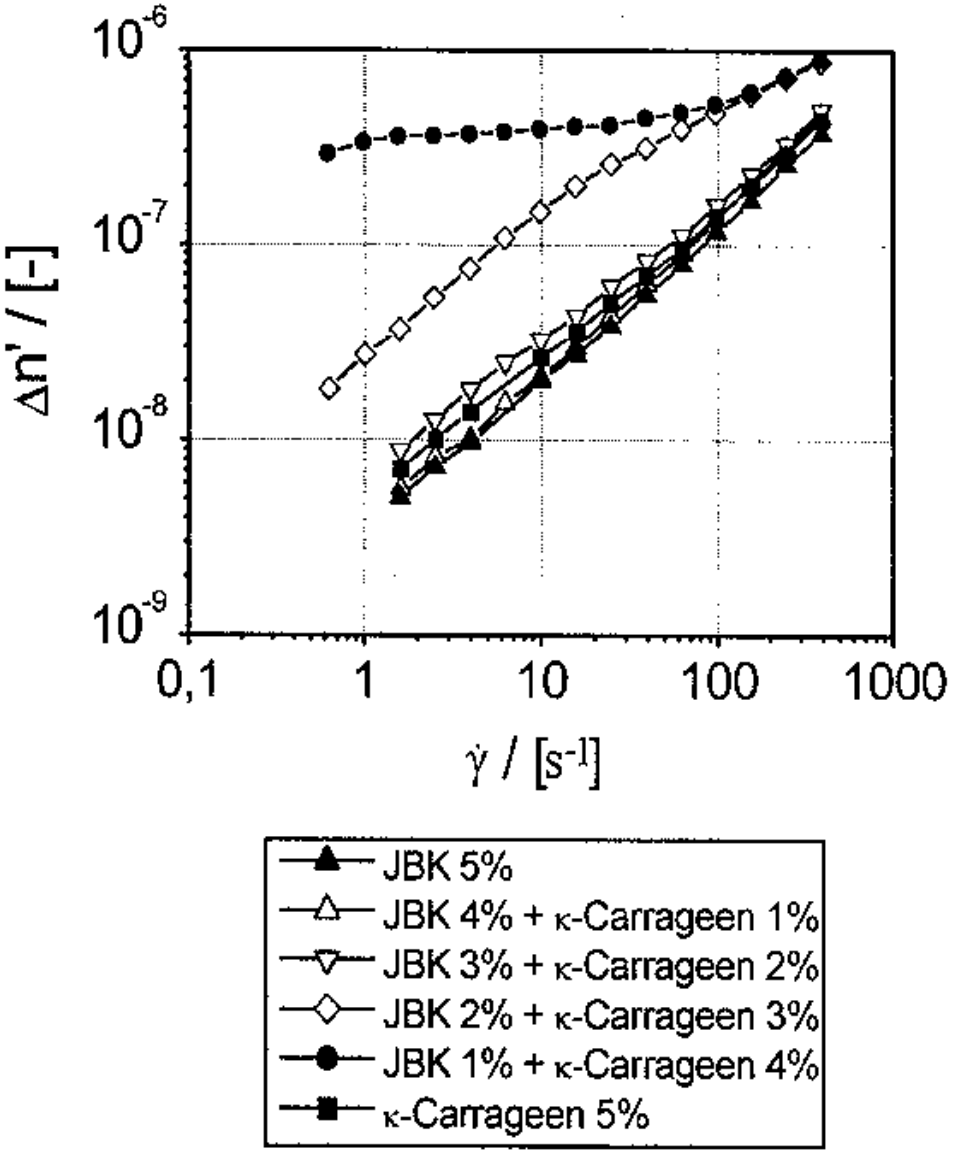


Food rheology

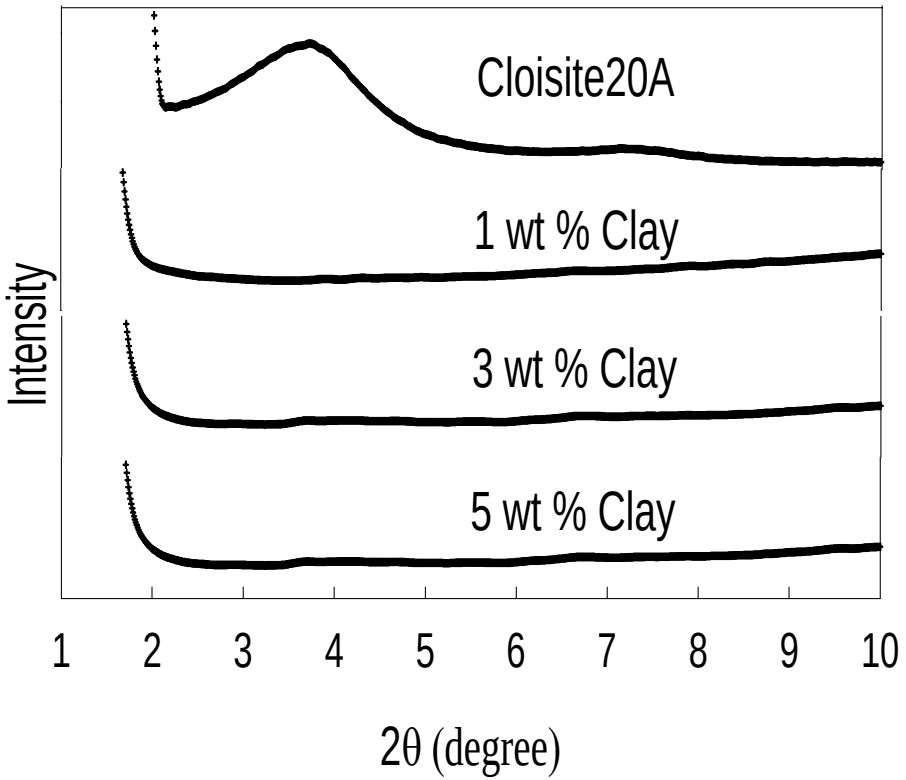


Locust bean gum/k-carrageenan

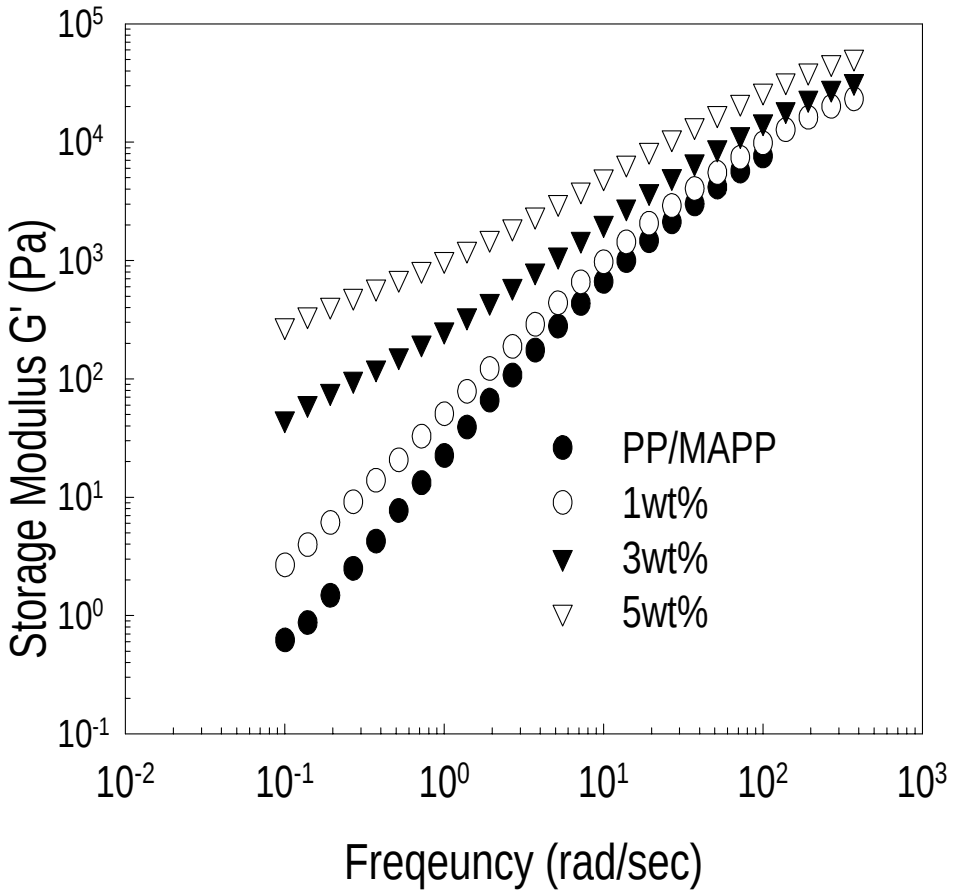




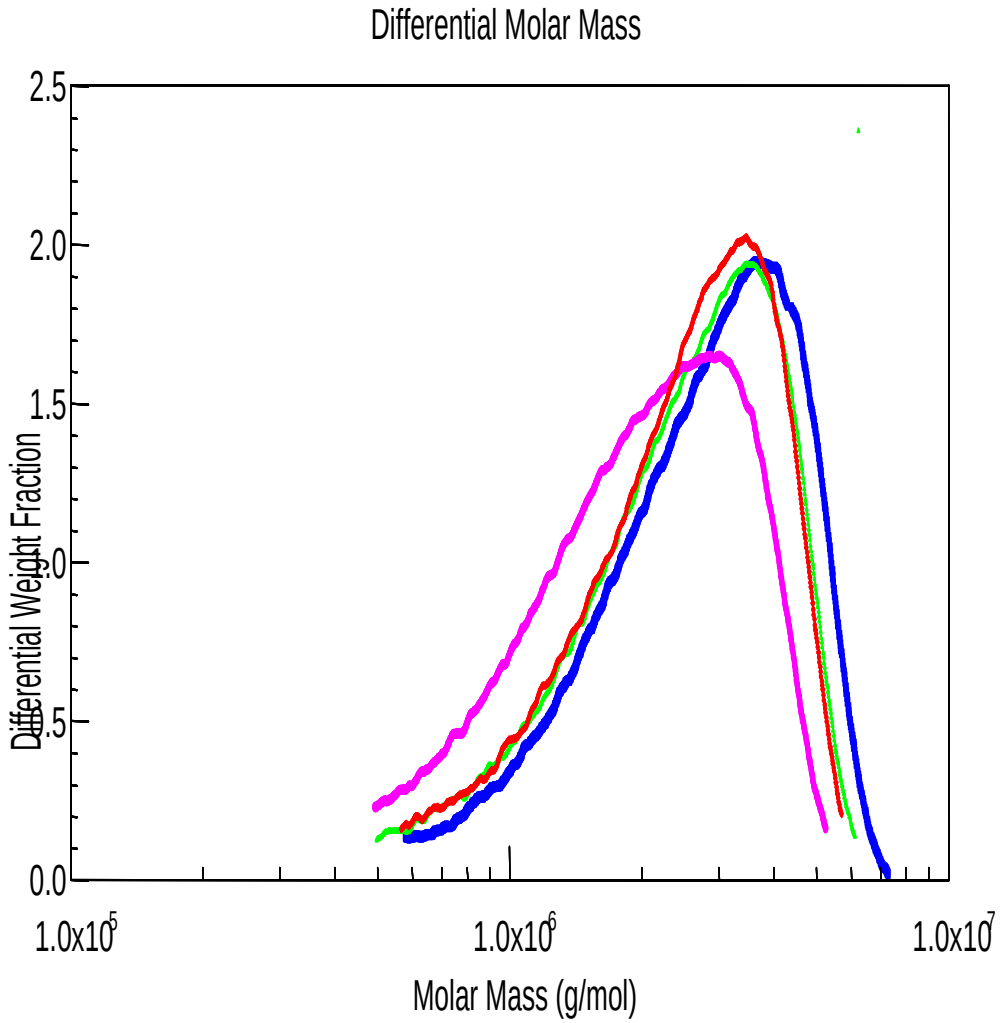
PP/MAPP/clay


Cloisite20A
1 wt % Clay
3 wt % Clay
5 wt % Clay
Intensity
1
2
3
4
5
6
7
8
9
10
2θ (degree)

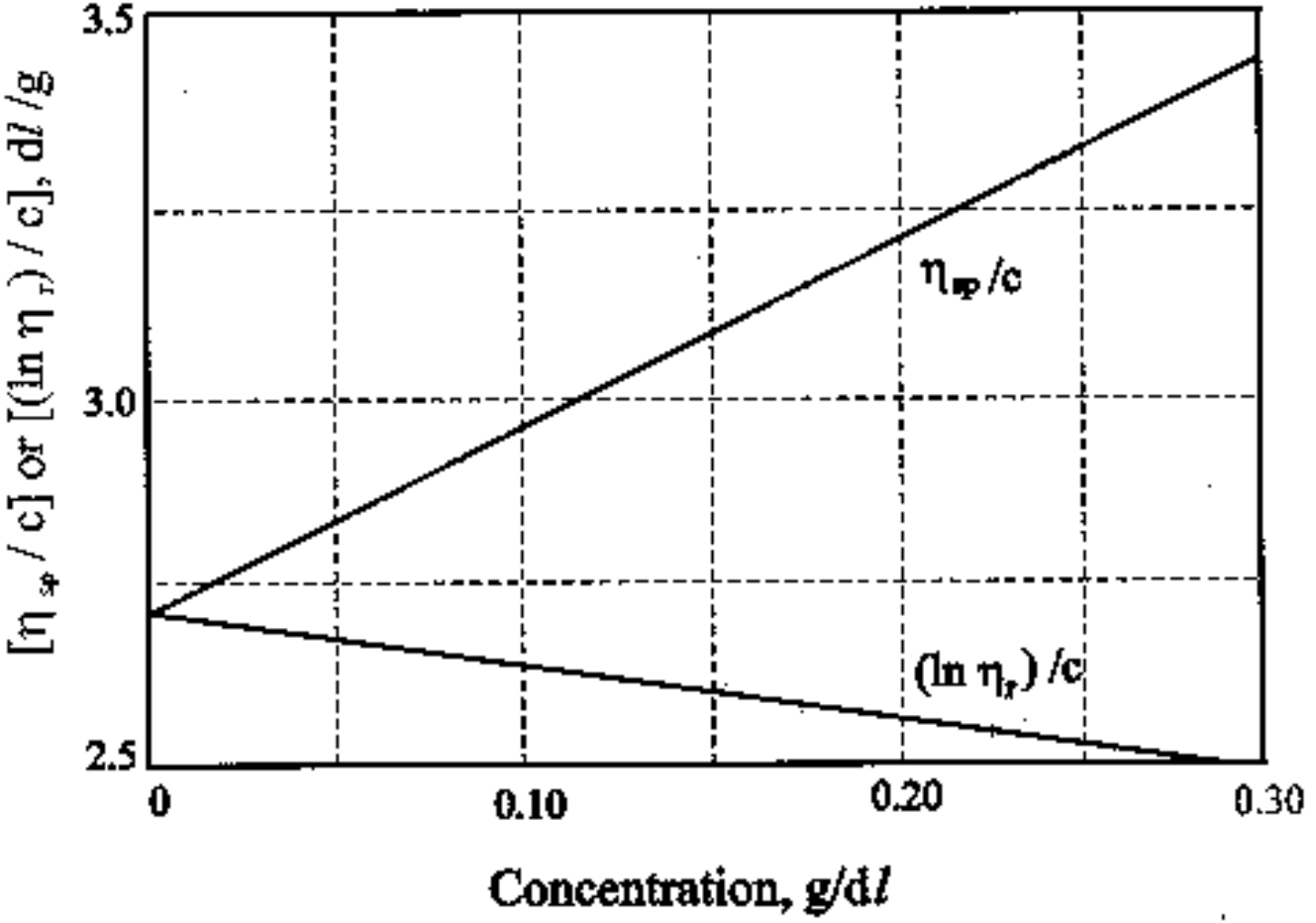
PP/MAPP/clay


Storage Modulus G' (Pa)
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Freqeuncy (rad/sec)
PP/MAPP
1wt%
3wt%
5wt%

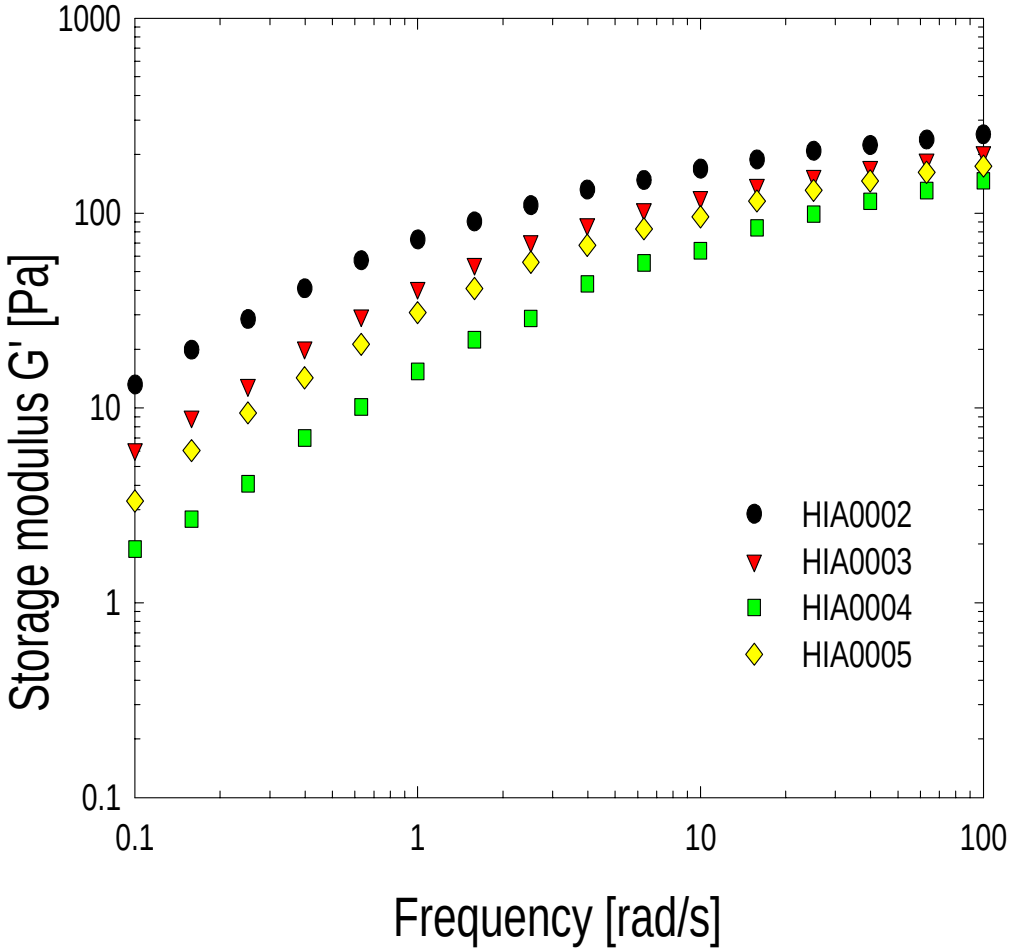
Hyaluronic acid (GPC/MALLS)



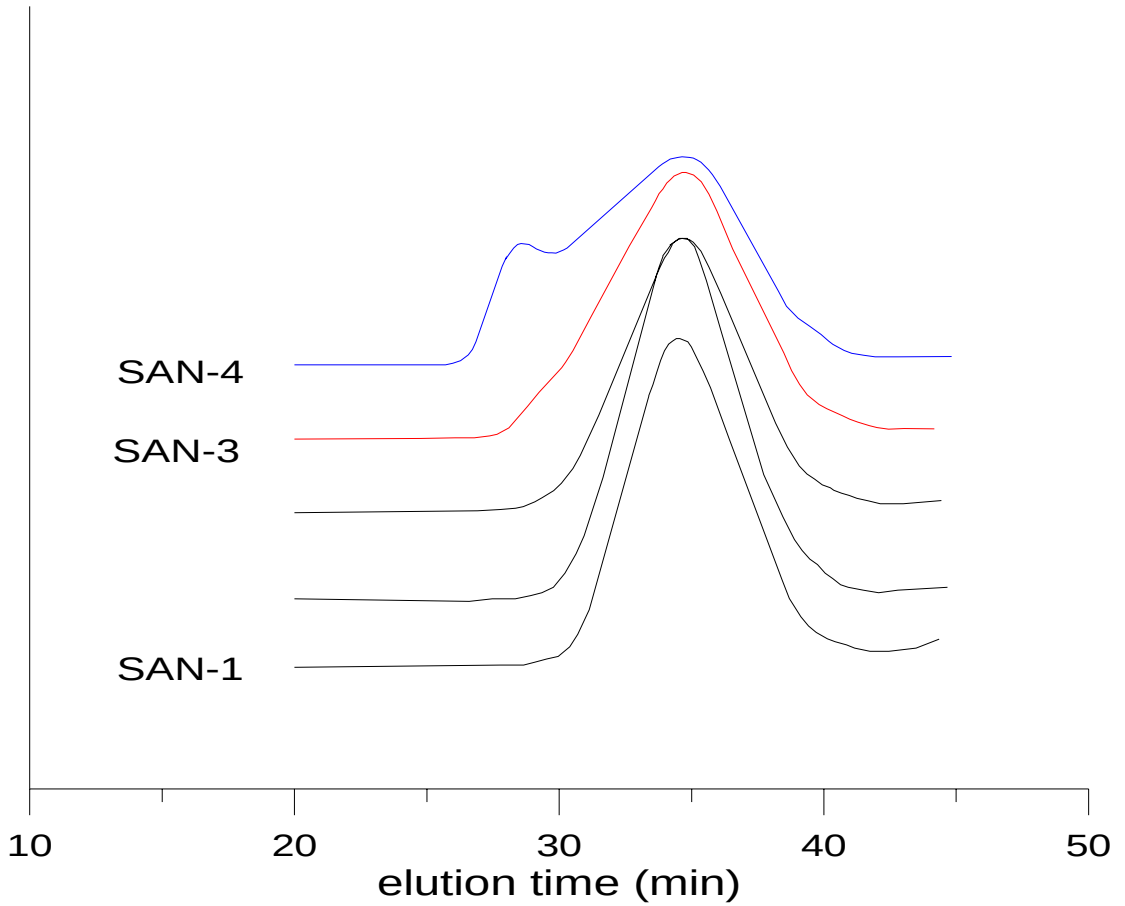
MW	PDI
2880k	1.35
2590k	1.36
2120k	1.43
2690k	1.35



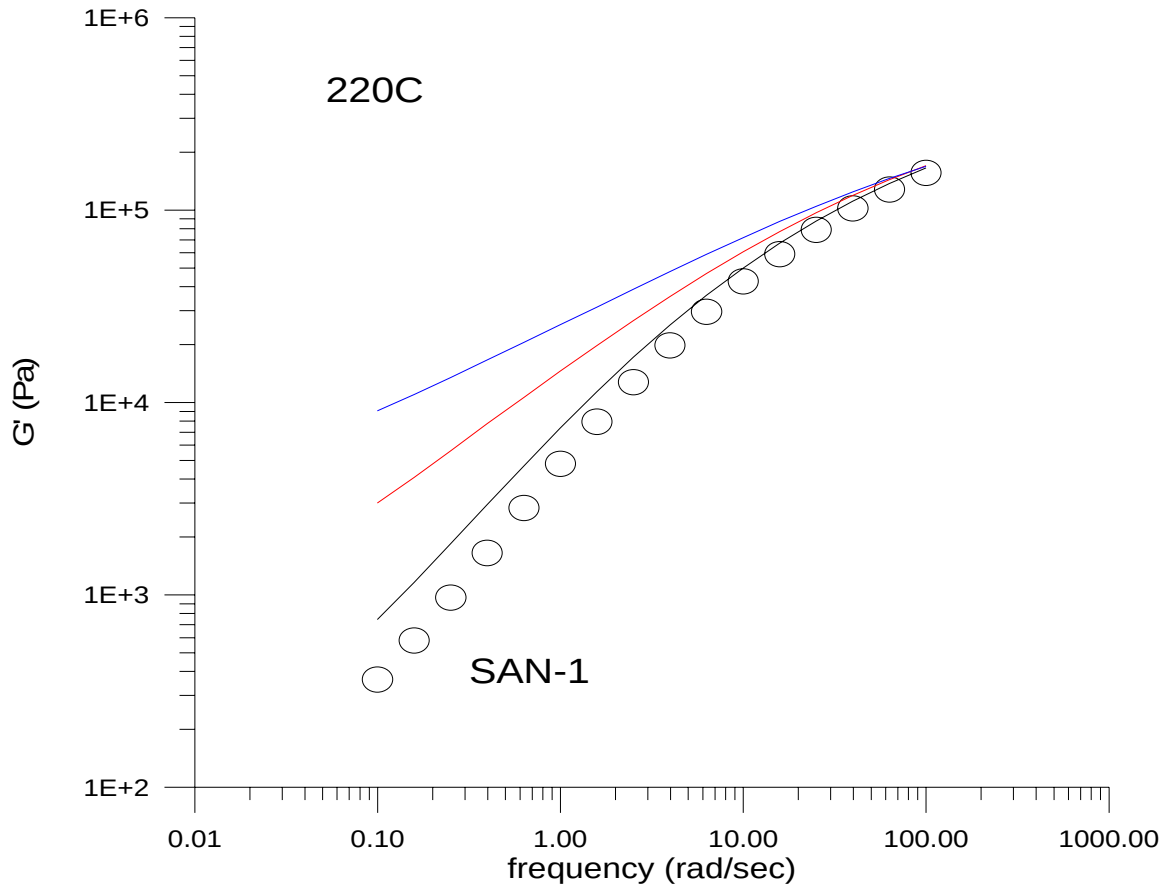
Typical curve for polystyrene in benzene


1000
100
10
1
0.1
Storage modulus G' [Pa]
0.1
1
10
100
Frequency [rad/s]
HIA0002
HIA0003
HIA0004
HIA0005

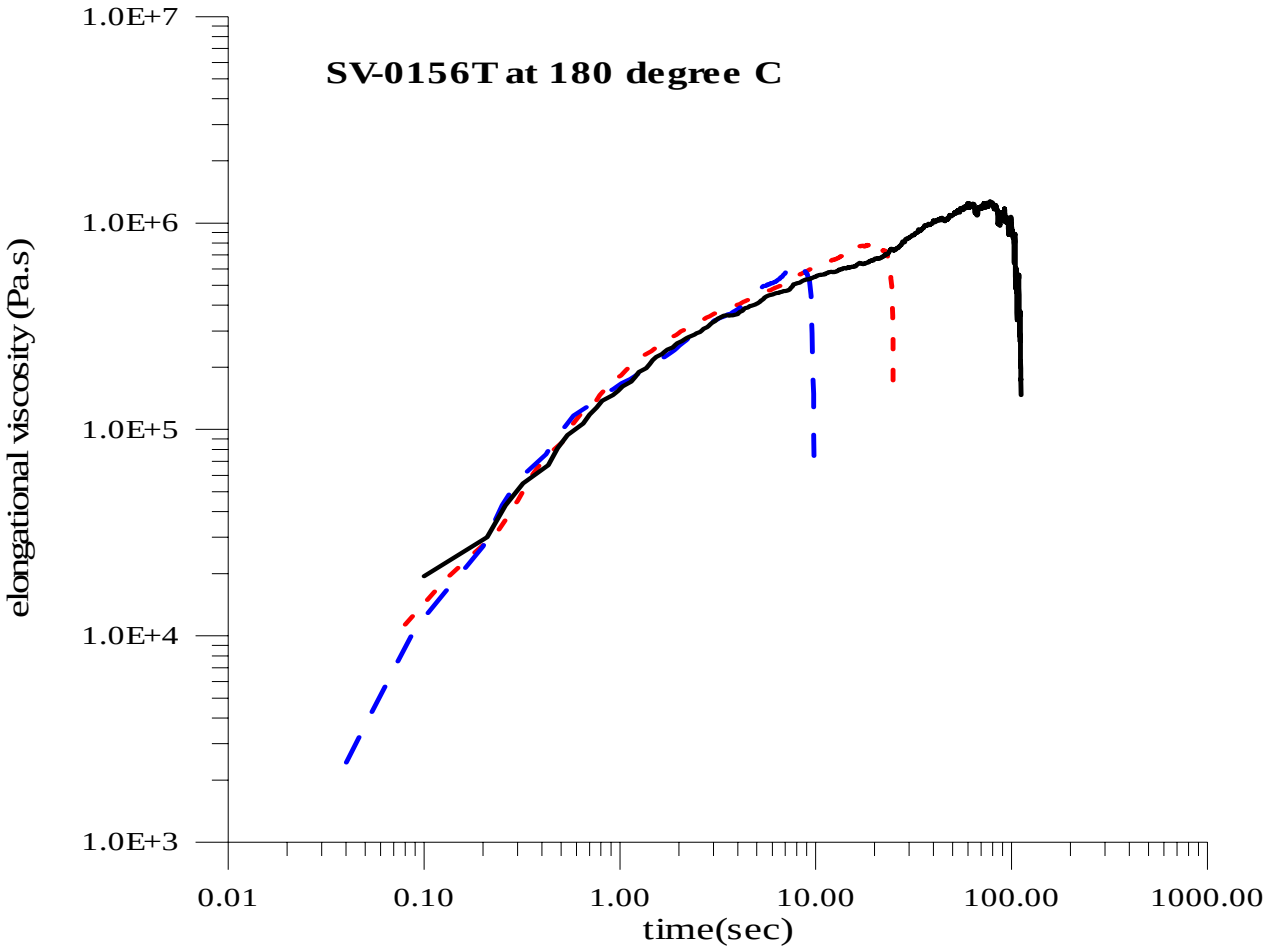
ABS수지개발 (GPC)



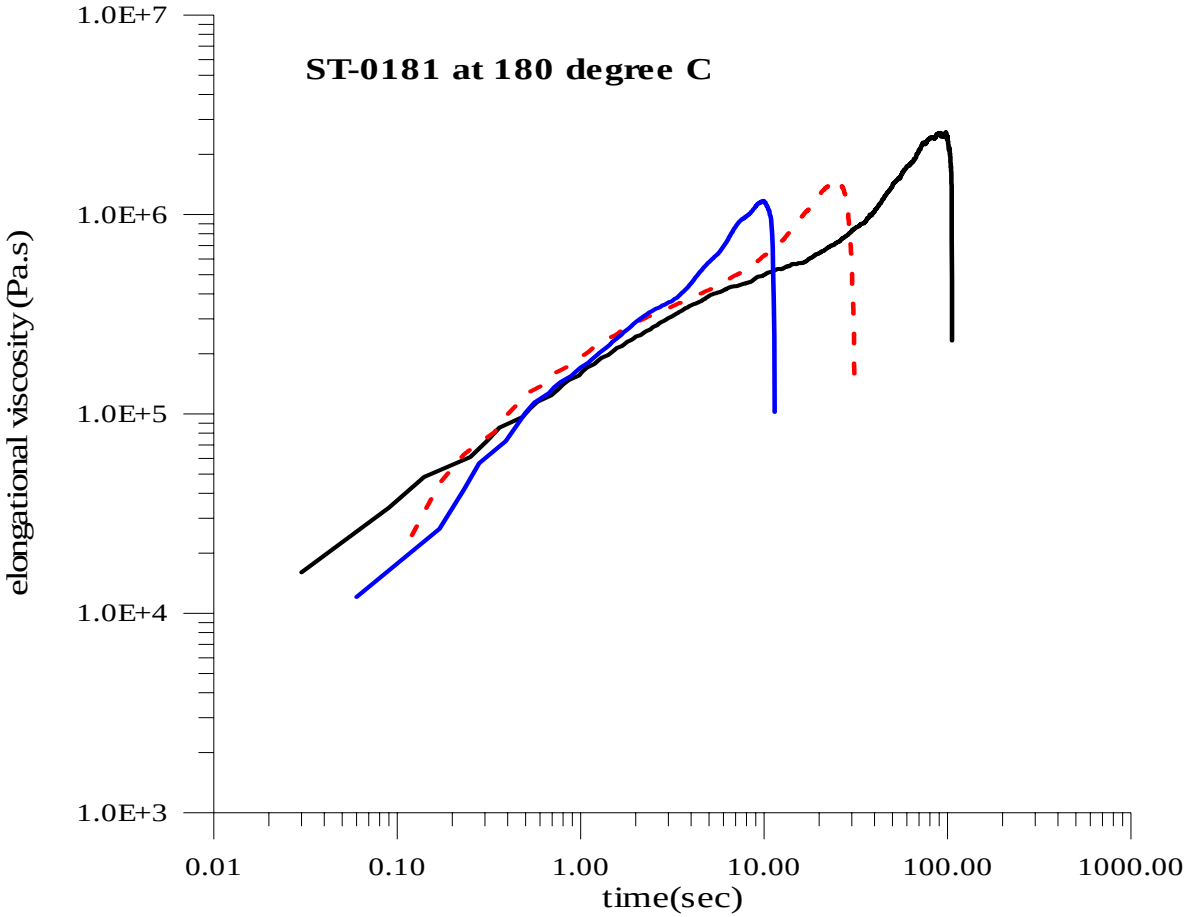
G’(storage modulus)



Elongational viscosity

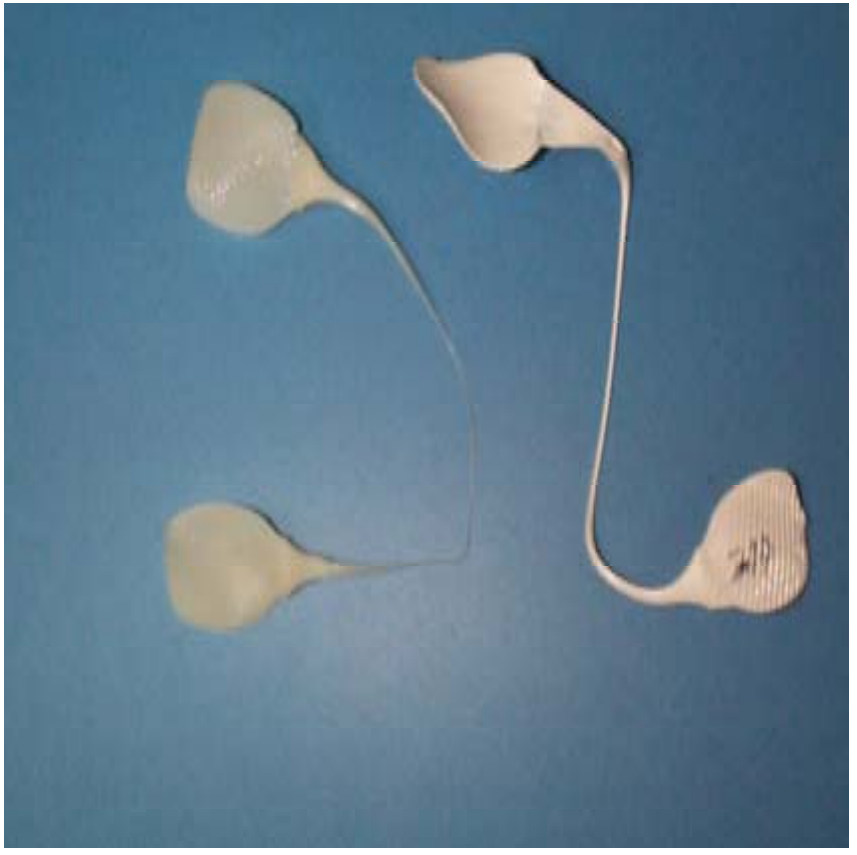


Elongational viscosity



ABS

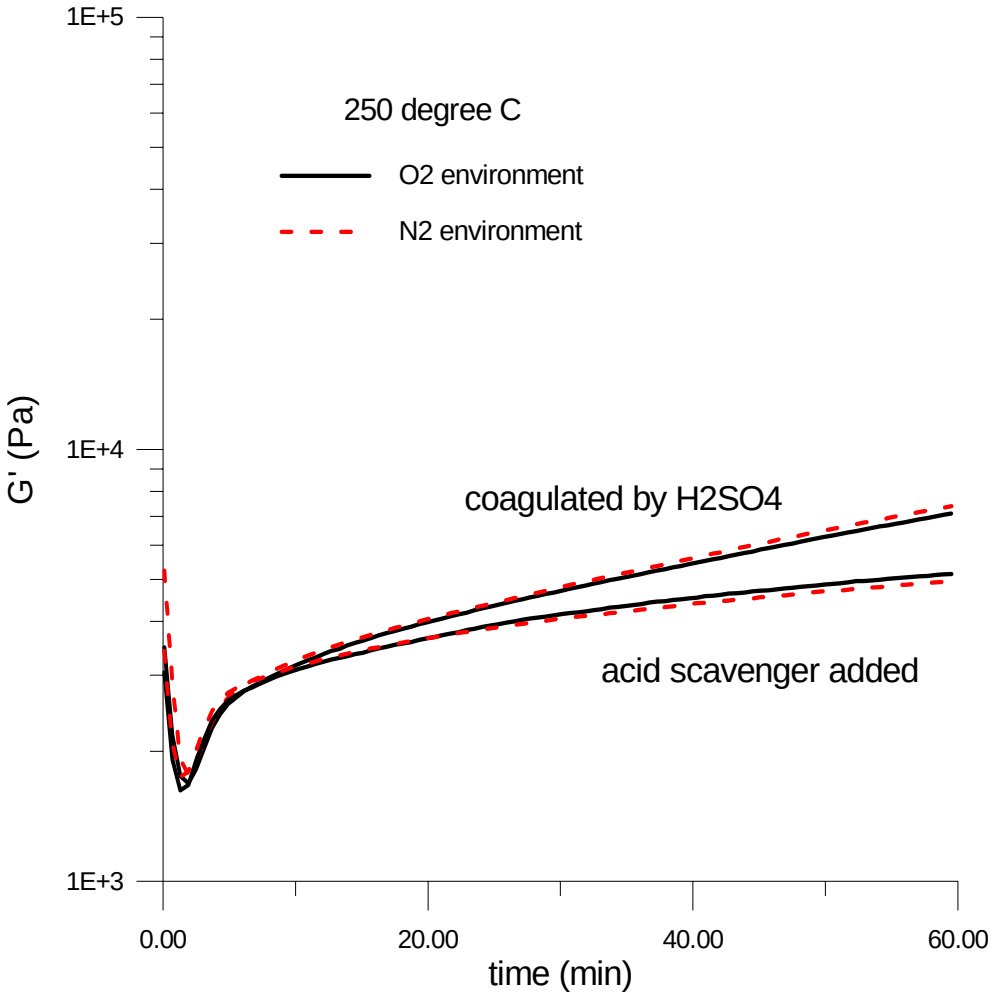
ABS



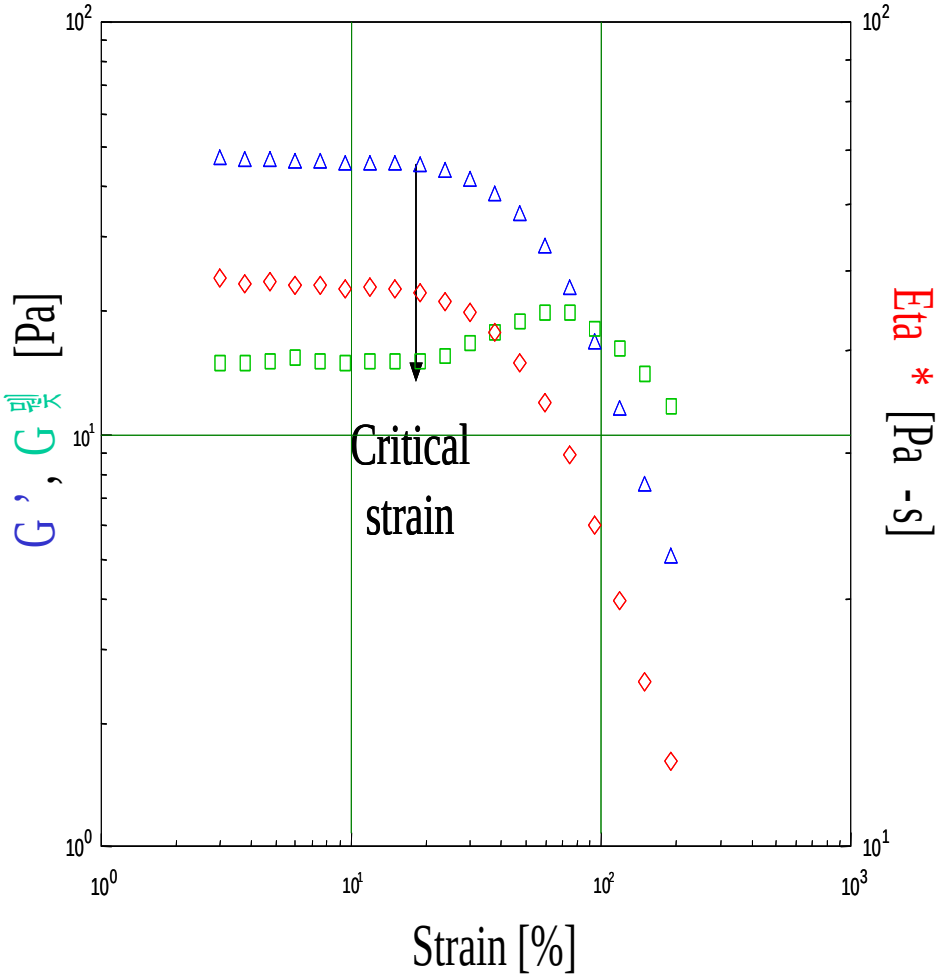
Rotational rheometer

- 시편제조상의 유의할 점
- 열안정성
- Strain sweep
- 관성 (inertia)의 영향
- 증발의 영향
- 시료의 안정성
- 기계적 영향
- 기타

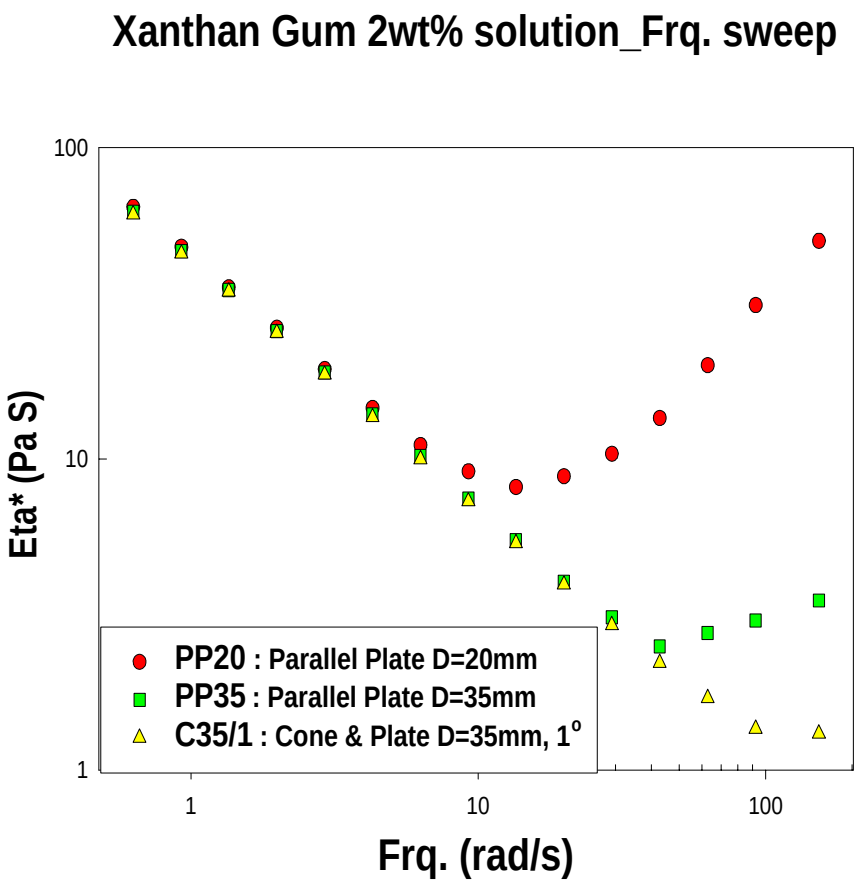
Thermal stability



Strain sweep

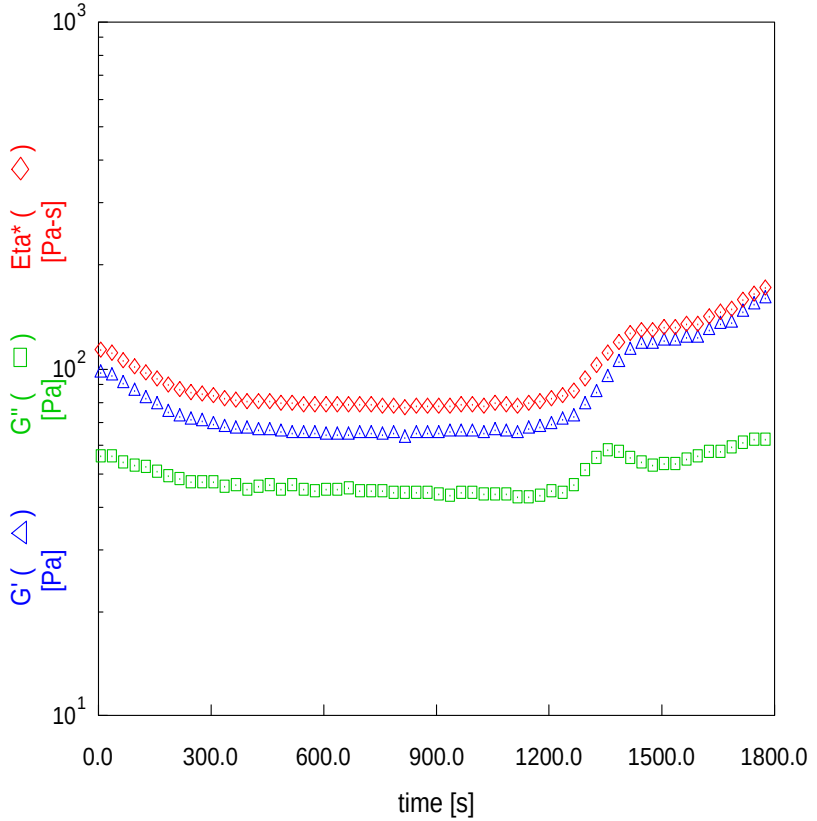


Inertia effect

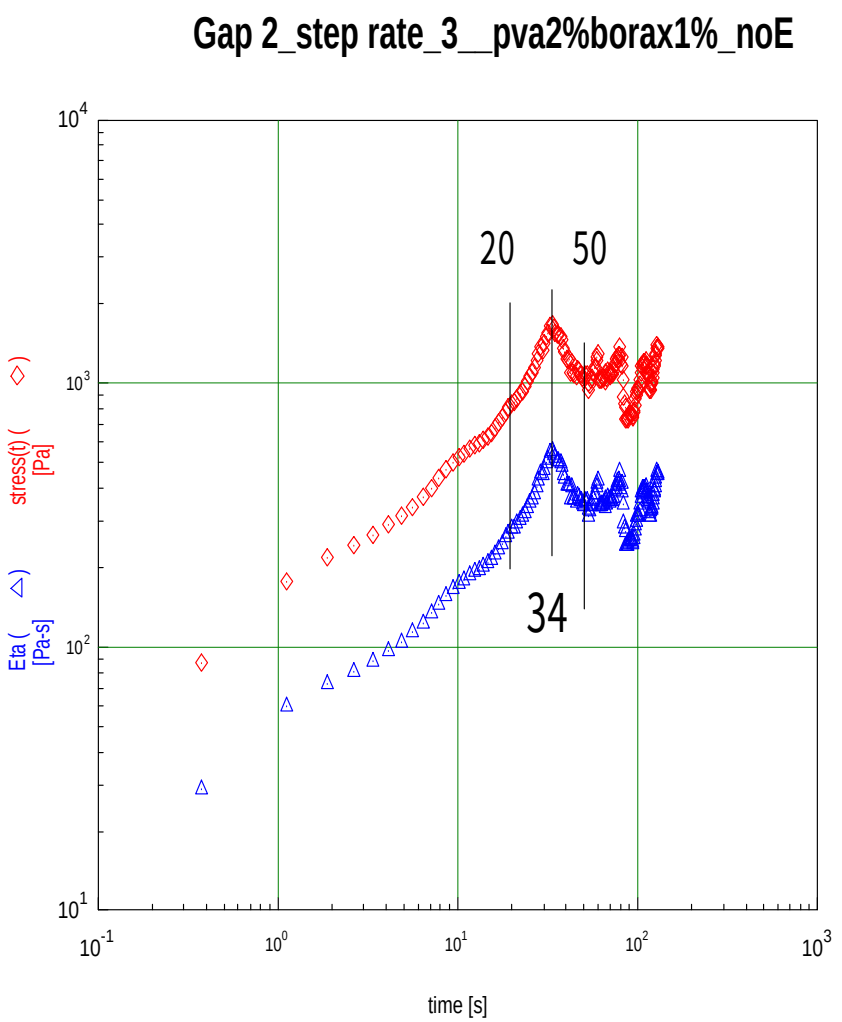


evaporation

W/O silicone oil



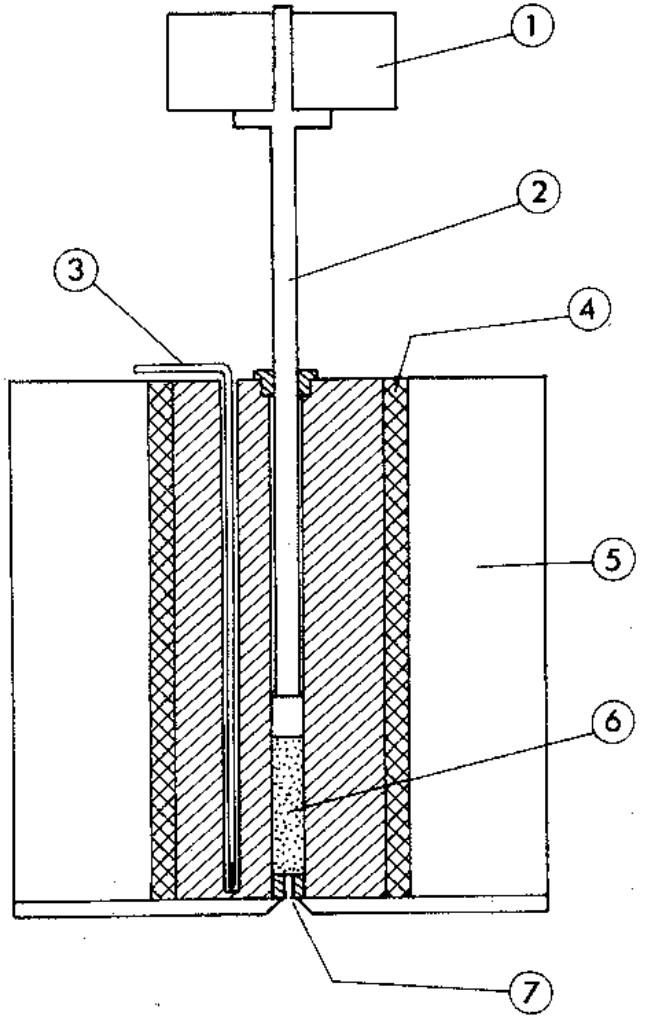
stability

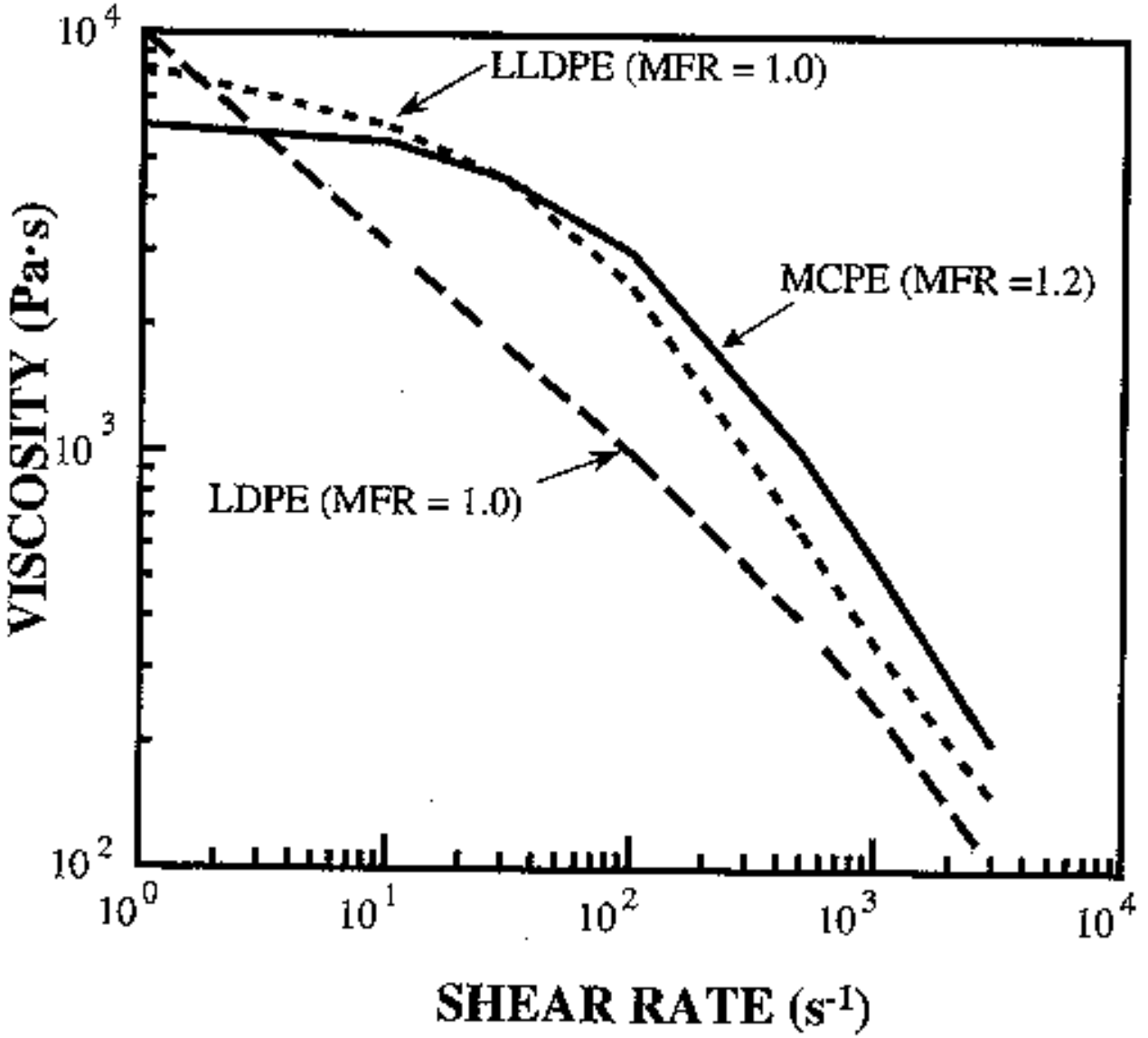

Gap 2_step rate_3__pva2%borax1%_noE
20
50
34
stress(t) (◇) [Pa]
Eta (△) [Pa-s]
time [s]
10^4
10^3
10^2
10^1
10^-1
10^0
10^1
10^2
10^3

At t=15s

At t=25s

Melt flow index (MI)





Conclusions

- 유용성
  - 품질관리, trouble-shooting, design etc.
- 다양성
  - Polymer, food, bio, phamaceutical, paint etc.
- 유의성
  - 실험, 해석
  - Experts
- Challenge
  - New concept/tool