Rheological properties of 2 grades of Polypropylene

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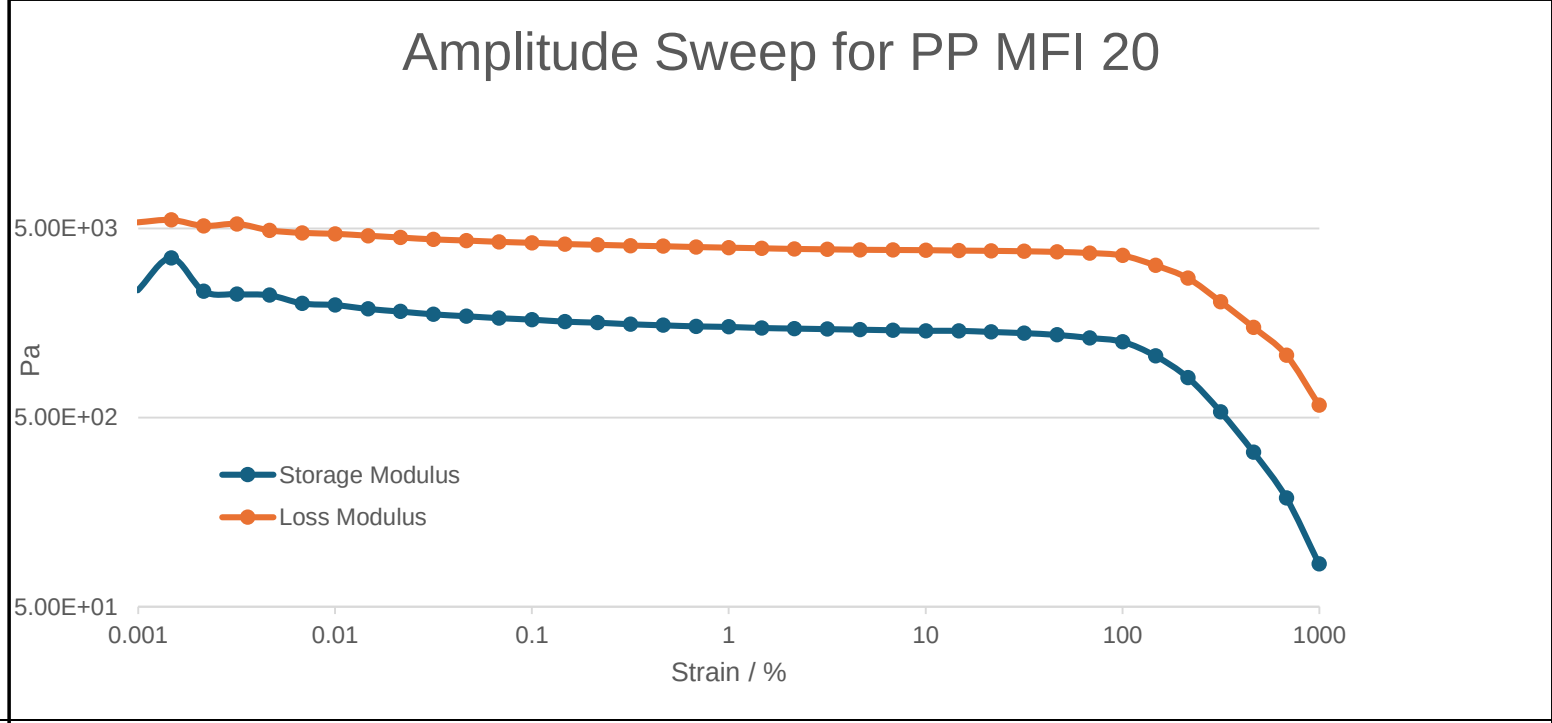
Apparatus and Materials

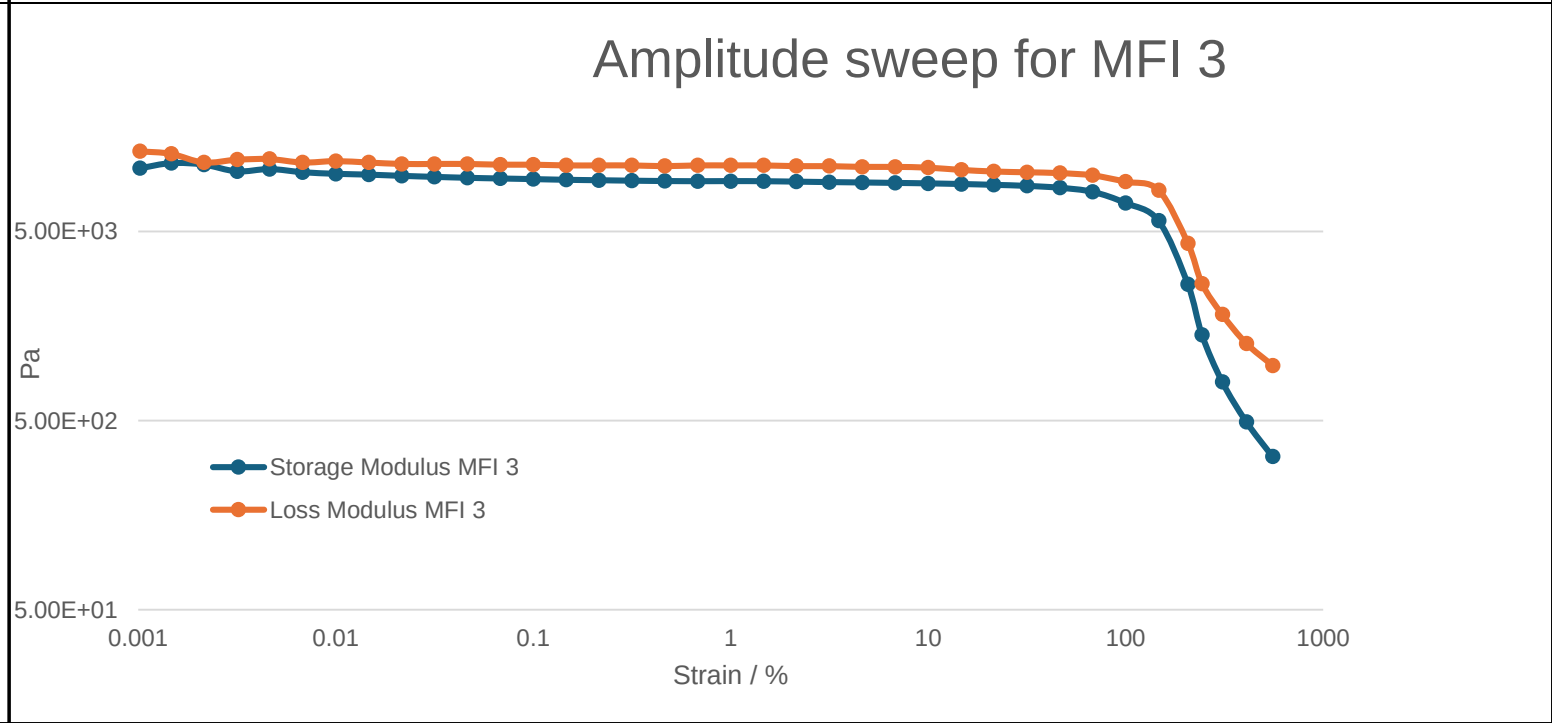
- PP MFI 20 g/10min
- PP MFI 3 g/10min

- Instrument: Rheometer
  - Conducted an amplitude sweep at 230℃
  - Conducted frequeny sweeps across temperatures (170℃, 200℃, 230℃, and 260℃)
  - Frequency sweep: 0.5 rad/s to 500 rad/s (Strain = 5%)
  - Amplitude sweep: Strain = 0.01% to 1000% (Frequency = 10 rad/s)

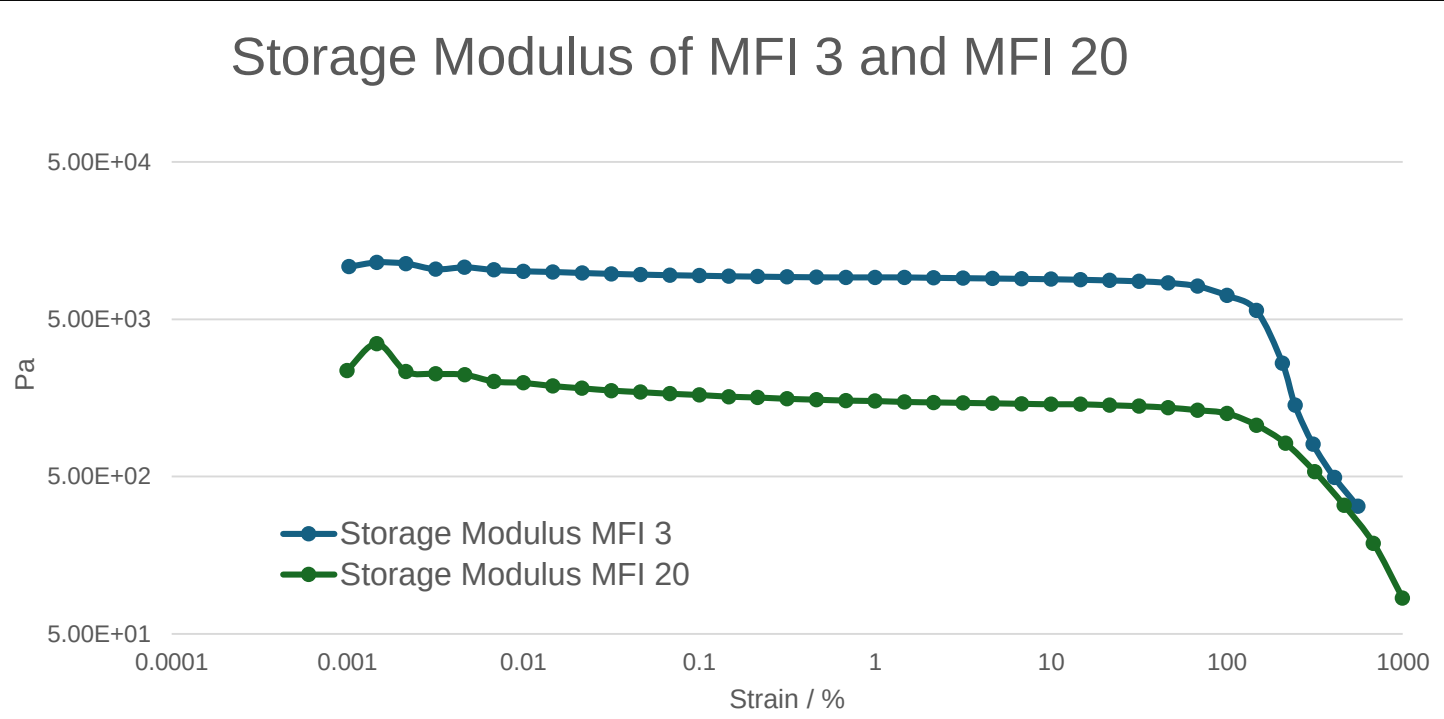
- Yield point = 100%
- Decrease in elastic character at higher strain
- No intersection: Dominated by liquid character and prone to deformation (Fluid)



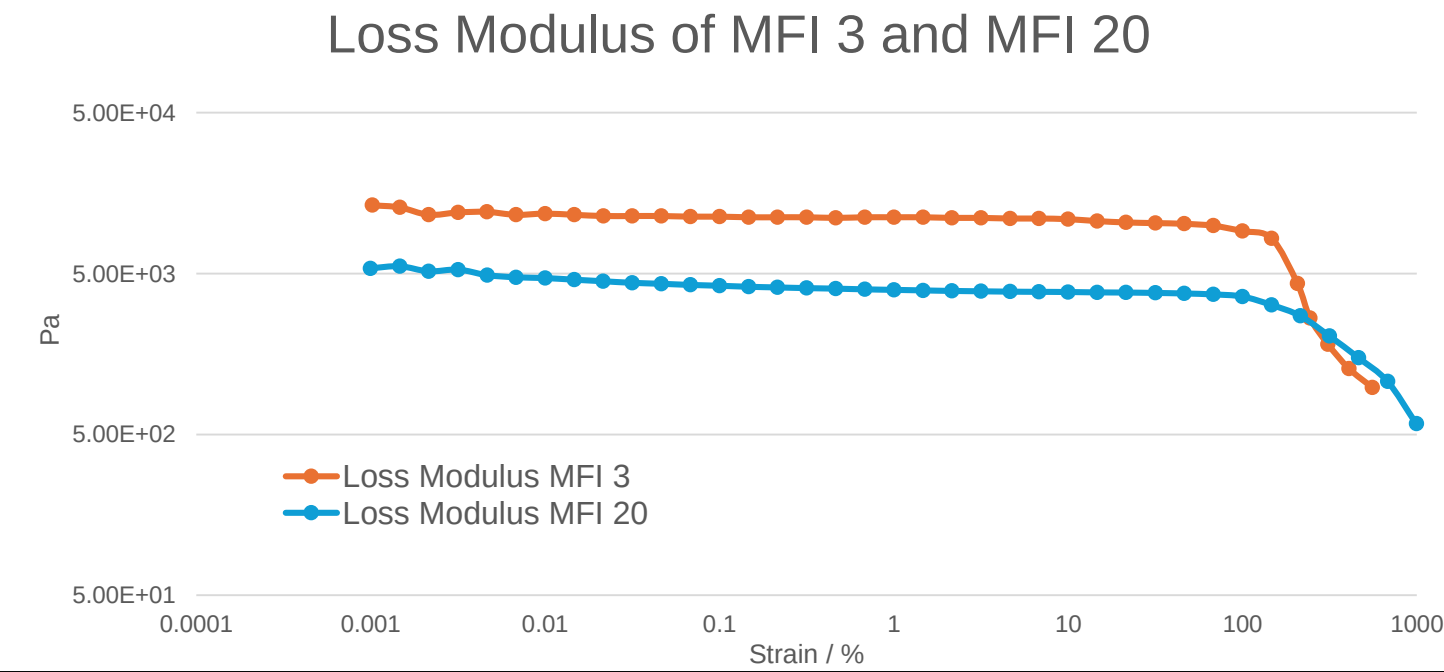
- Yield point around 100% strain
- No intersection indicates liquid character dominates (Fluid)

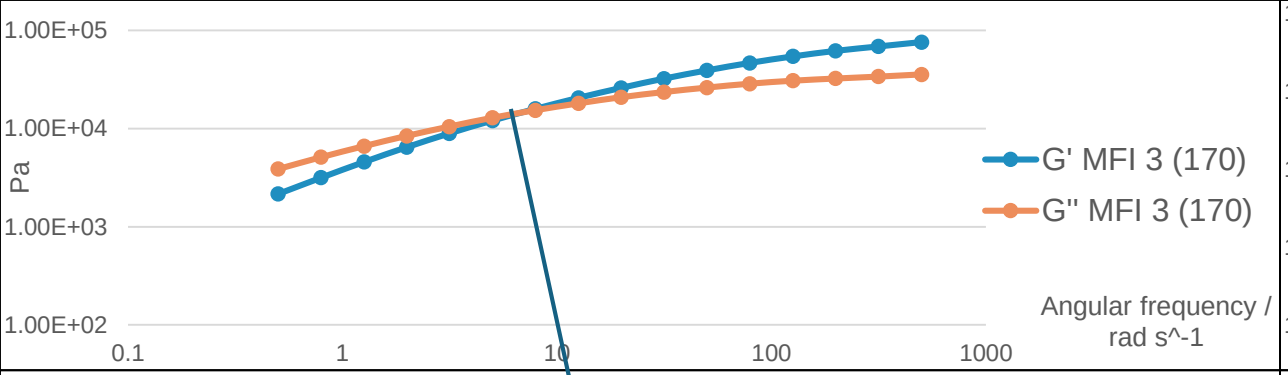


- On average, G' of MFI 3 is much higher than MFI 20
- Indicates MFI 3's greater viscoelasticity leads to greater resistance to deformation
- Both are fluid, but MFI 3 has greater solid character and is better for extrusion



- G" of MFI 3 is much higher that of MFI 20.
- MFI 3 shows a greater viscous component than MFI 3
- MFI 20 is better for injection molding as its G" is much higher than its G'




1.00E+05
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Pa
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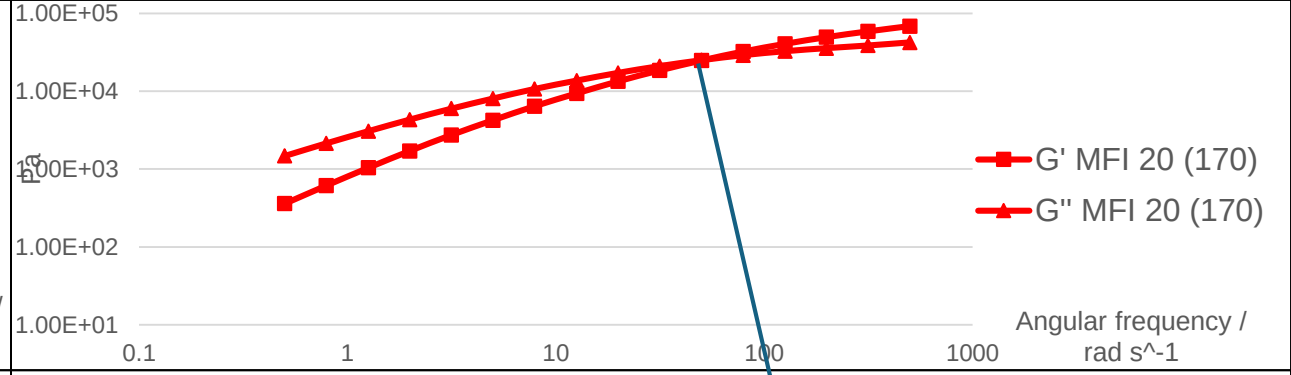
Angular frequency / rad s^-1
G' MFI 3 (170)
G'' MFI 3 (170)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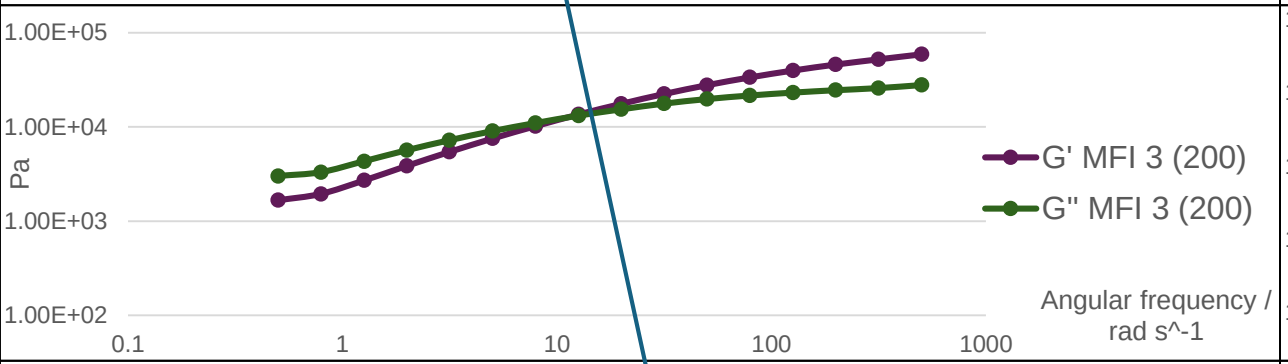
Angular frequency / rad s^-1
G' MFI 20 (170)
G'' MFI 20 (170)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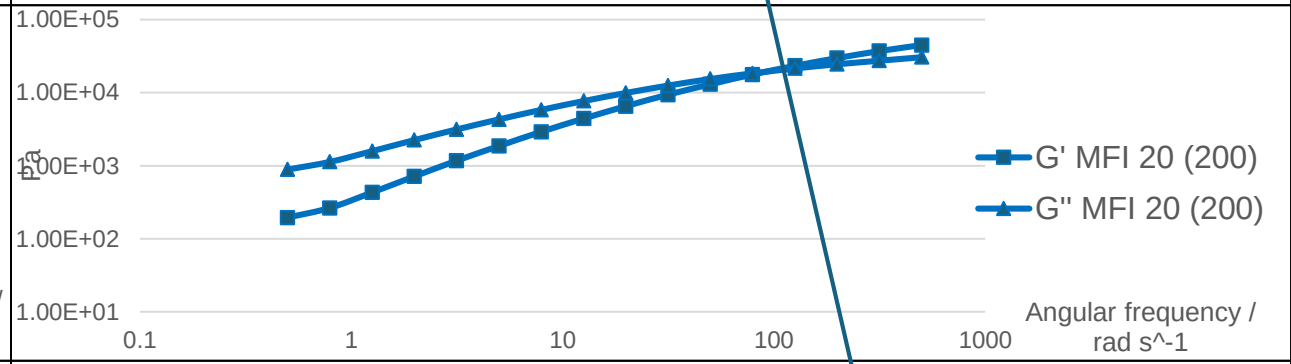
Angular frequency / rad s^-1
G' MFI 3 (200)
G'' MFI 3 (200)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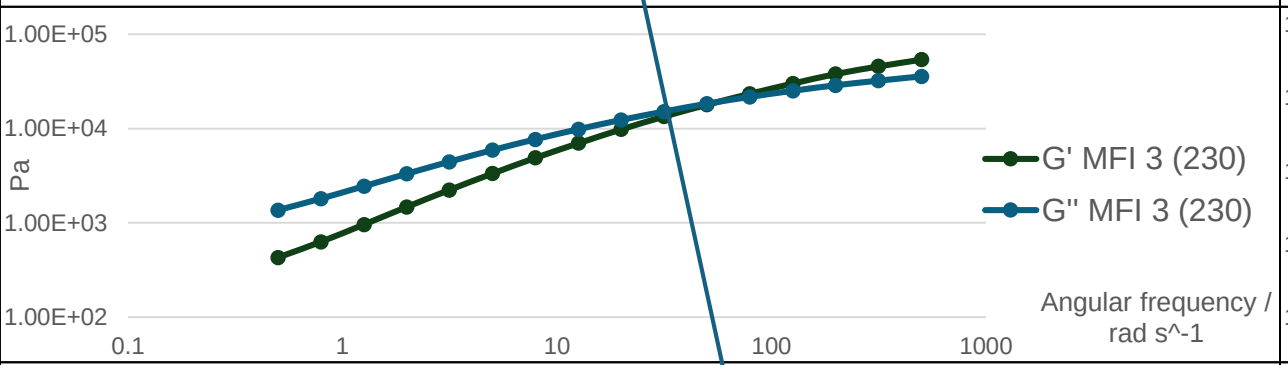
Angular frequency / rad s^-1
G' MFI 20 (200)
G'' MFI 20 (200)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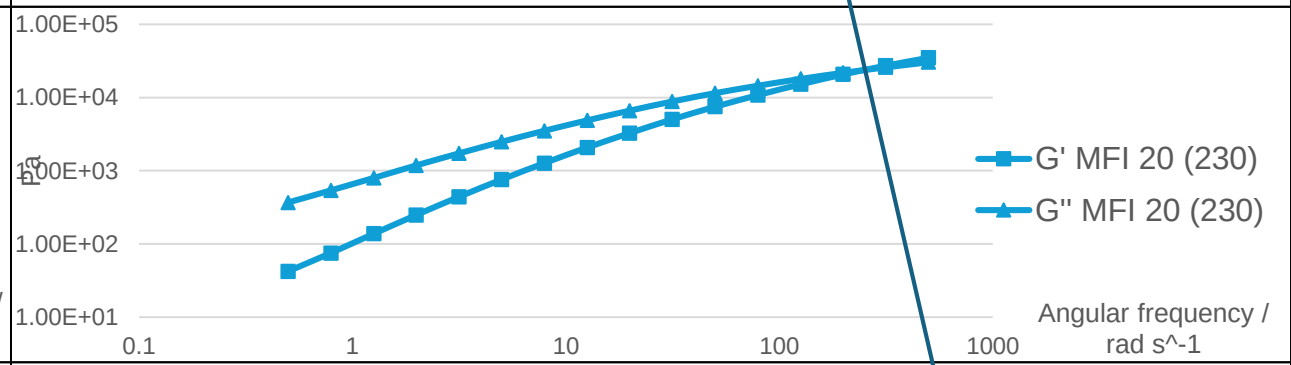
Angular frequency / rad s^-1
G' MFI 3 (230)
G'' MFI 3 (230)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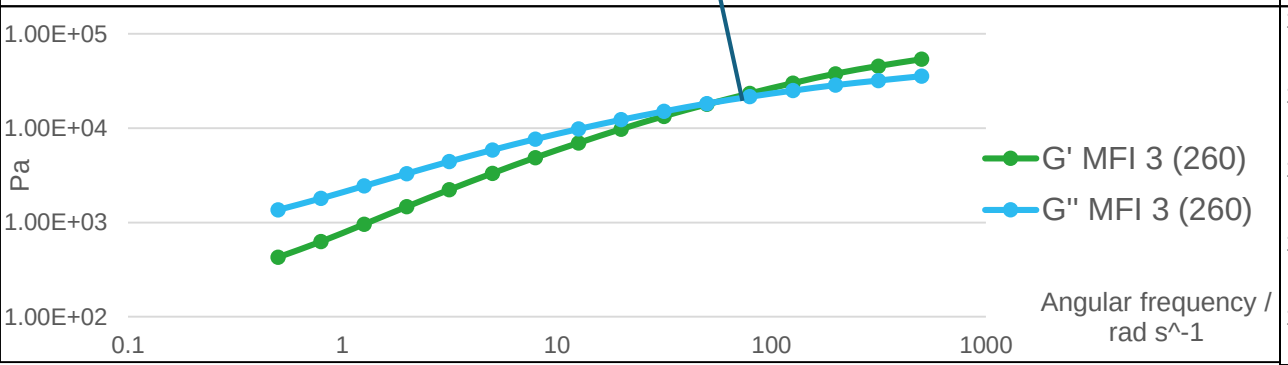
Angular frequency / rad s^-1
G' MFI 20 (230)
G'' MFI 20 (230)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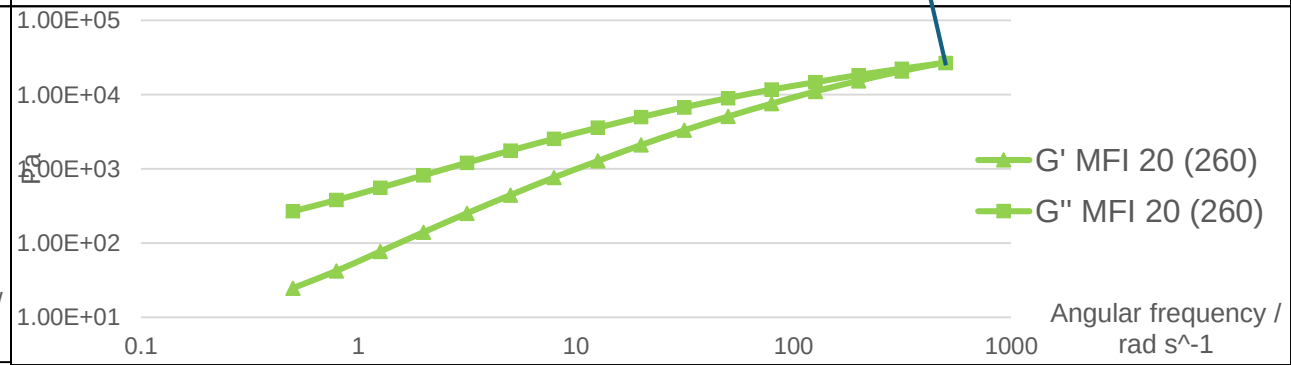
Angular frequency / rad s^-1
G' MFI 3 (260)
G'' MFI 3 (260)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1.00E+02
1.00E+01
Pa
0.1
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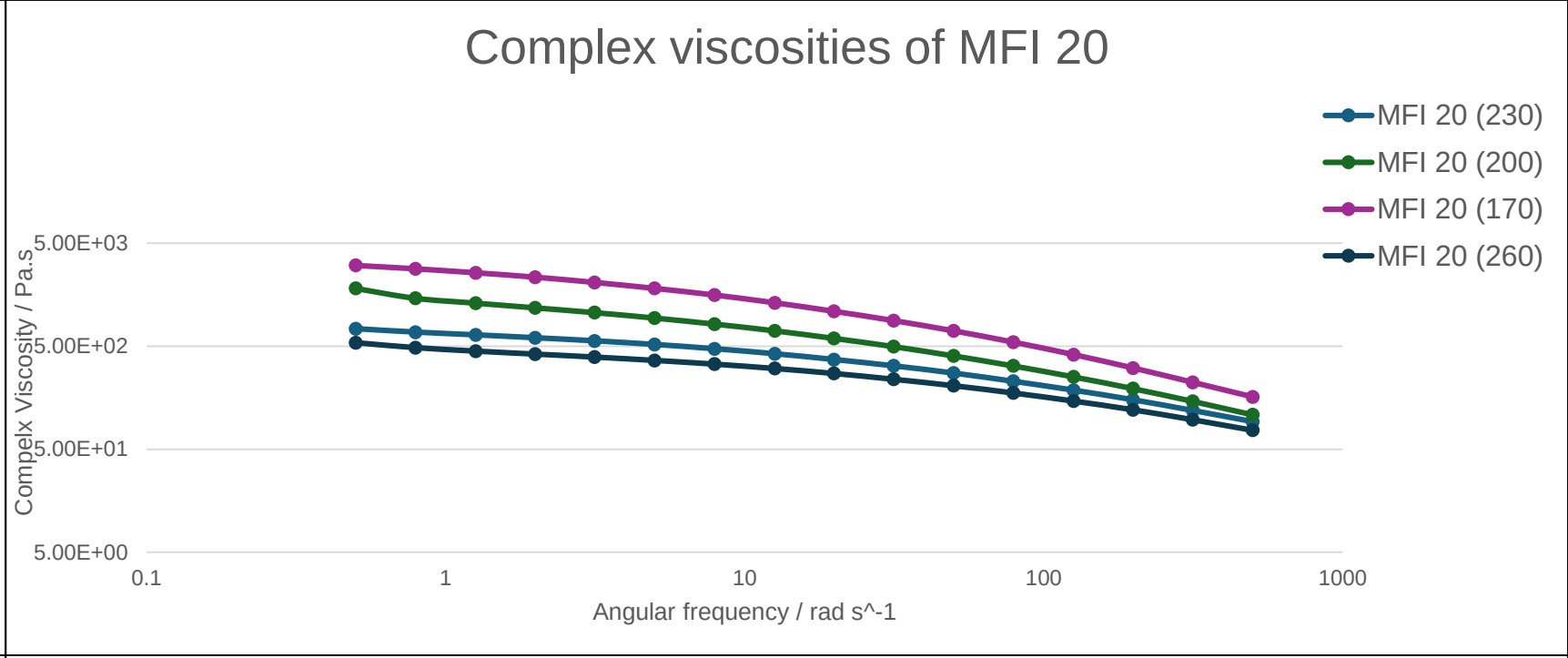
10
100
1000
Angular frequency / rad s^-1
G' MFI 20 (260)
G'' MFI 20 (260)

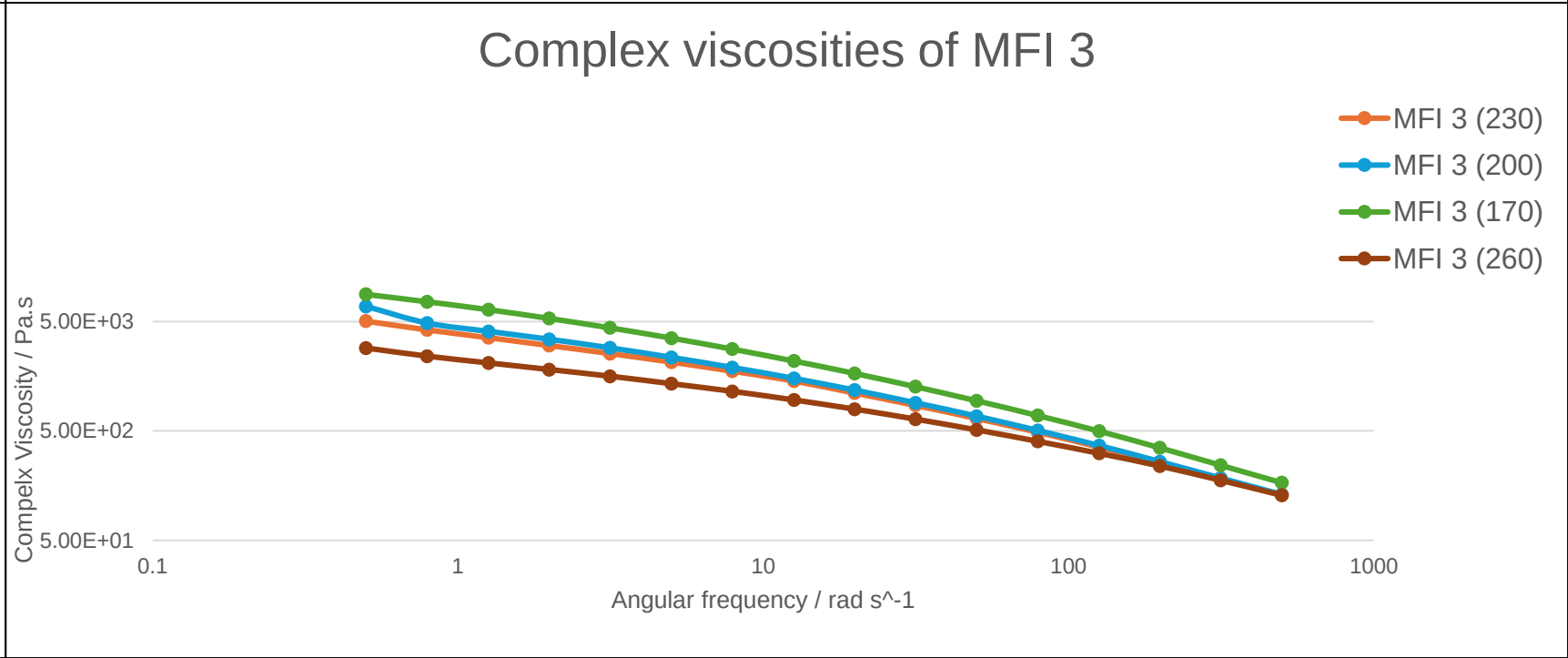
Frequency sweep MFI 20 and MFI 3 - Interpretation

Frequency sweep at 170℃ (MFI 20) • G'' = G' at around 80 rad/s • Fluid behavior dominates over gel-like, but resists deformation better than samples at 200°C, 230°C, and 260°C	**Frequency sweep at 170℃ (MFI 3)** • G'' = G' at 7 rad/s • Resists deformation and demonstrates solid gel-like behavior better than all other samples and is therefore most suitable for blown-film extrusion
Frequency sweep at 200℃ (MFI 20) • G'' = G' at around 100 rad/s • Fluid behavior dominates at lower shear rate, but resists deformation better than higher temperatures	**Frequency sweep at 200℃ (MFI 3)** • G'' = G' at 12 rad/s • Resists deformation and demonstrates solid gel-like behavior better than at 230°C
Frequency sweep at 230℃ (MFI 20) • Storage modulus exceeds loss modulus after around 200 rad/s • Deforms at lower frequencies due to increase fluidity	**Frequency sweep at 230℃ (MFI 3)** • Storage modulus exceeds loss modulus after around 30 rad/s • Sample resists deformation as G'>G'' at higher frequency
Frequency sweep at 260℃ (MFI 20) • G'<G'' throughout • Prone to deformation at higher frequencies as well. Appears to plateau and should crossover at higher frequencies	**Frequency sweep at 260℃ (MFI 3)** • G'' = G' at 60 rad/s • Sample resists deformation as G'>G'' at higher frequencies only due to lower viscosity

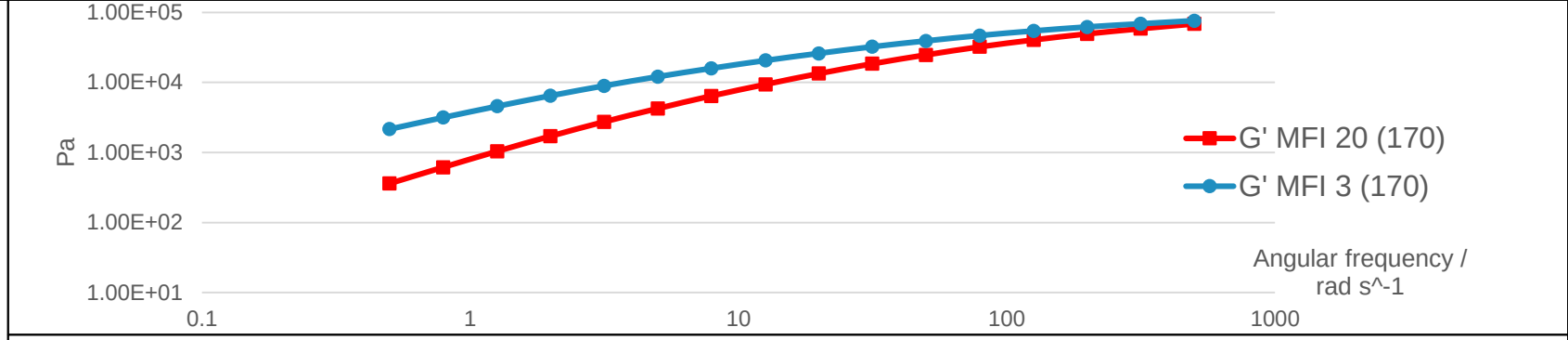
- As the temperature increases, the complex viscosity decreases.
- For each sample, there is an inverse relationship between the complex viscosity and the frequency. It shows shear thinning behavior (Non-Newtonian fluid).

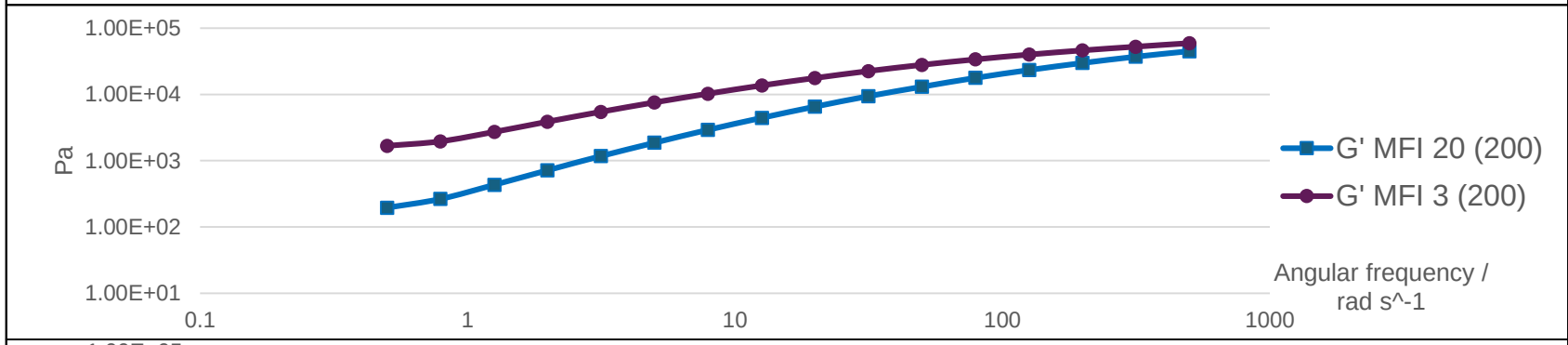


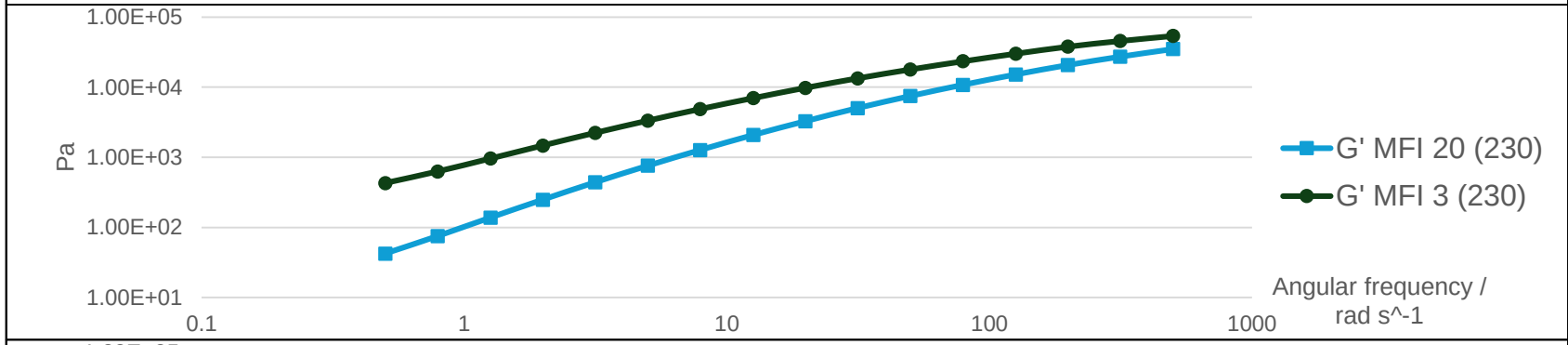
- There is a similar trend as the MFI 20 samples.
- The viscosity of each sample is higher than its MFI 20 counterpart at the same temperature due to the increased entanglement of MFI 3.

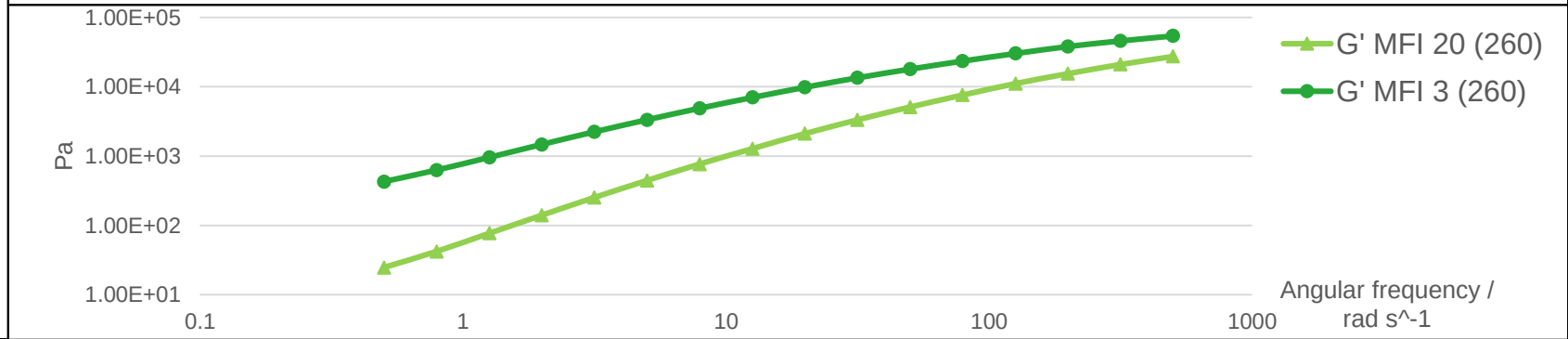


- With the amplitude sweep we can see MFI 3 has a consistently higher storage modulus than MFI 20 indicating a greater elastic component at all temperatures
- The storage modulus for MFI 20 and 3 decreases as temperature increases and begins to plateau at higher frequencies
- Due to the consistently higher storage modulus of MFI 3, it is able to resist deformation better and is suitable for blown film extrusion









- MFI 3 has a consistently higher storage modulus than MFI 20.
- At 170℃ and 200℃, MFI 20's G'' is higher at higher frequencies indicating that MFI 3's longer chains disentangle faster and lead to lower viscosities at higher frequencies
- In general, MFI 3 is more viscous across temperatures