



New formulations for consistent slip properties

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Outline

- **Use of slip additives in film**
- **Test methods for films containing slip**
- **Migratory nature of traditional slip agents**
- **Traditional non-migratory slip agents**
- **New formulations for consistent slip properties**

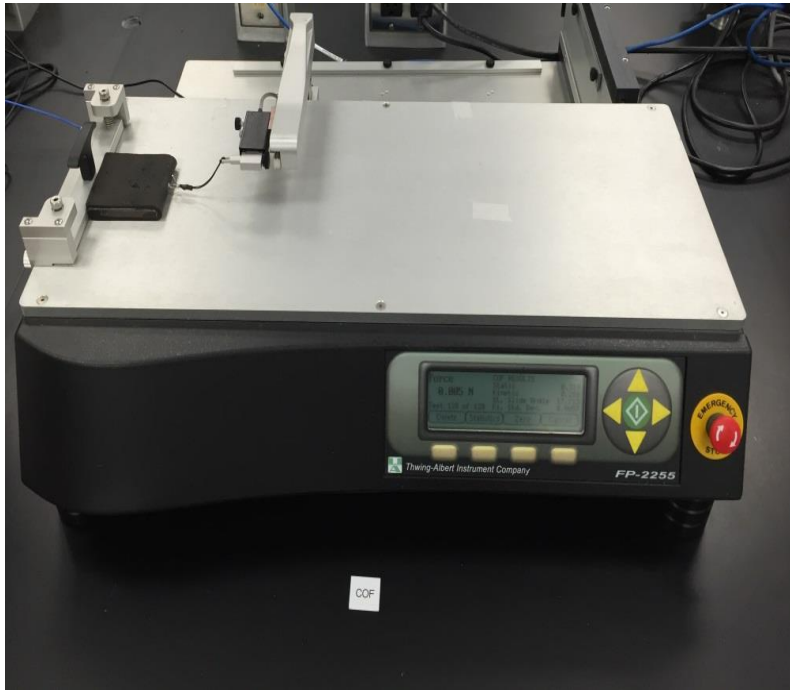
Use of masterbatches in film production

- **Ease of handling and feeding**
- **Controlled levels in film**
- **Improved incorporation in film**
- **Custom design of products to meet specific customer applications and targets**

Use of slip additives in film

- **Control of coefficient of friction (COF)**
- **Typically $\text{COF} < 0.2$ is desired**
- **Improved film extrusion and converting processes**
- **In traditional migratory slip additives performance is based on migration of additives to the surface**

Test methods for films containing slip

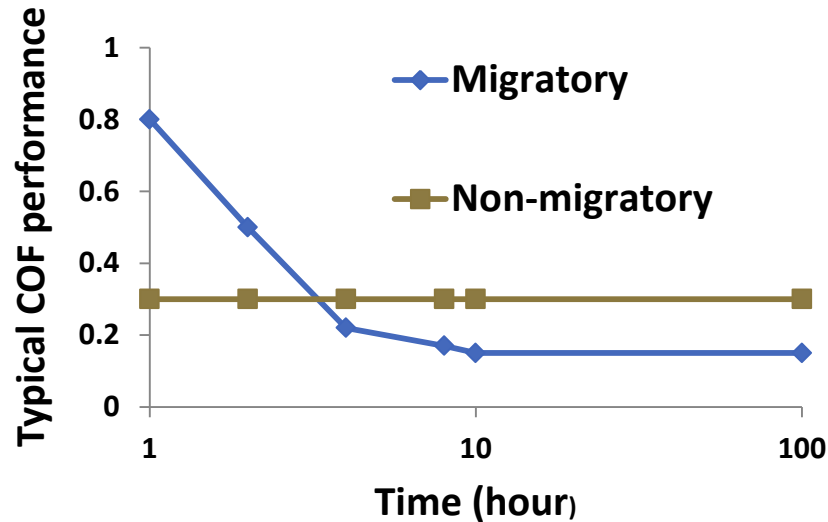


- **ASTM D1894 standard**
- **Typically film-on-film performance is tested**
- **Blocking tests per ASTM D3354**

Migratory versus non-migratory additives

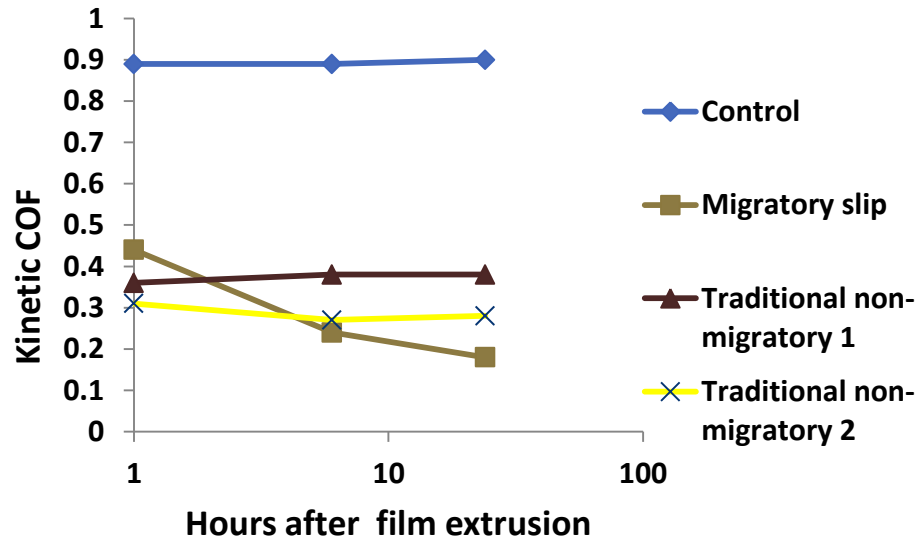
- **Typical migratory additives are long chain amides**
- **Typical non-migratory additives are polymeric in nature**
- **Sufficient additive has to be present to cover the surface in both systems**

Traditional slip additives



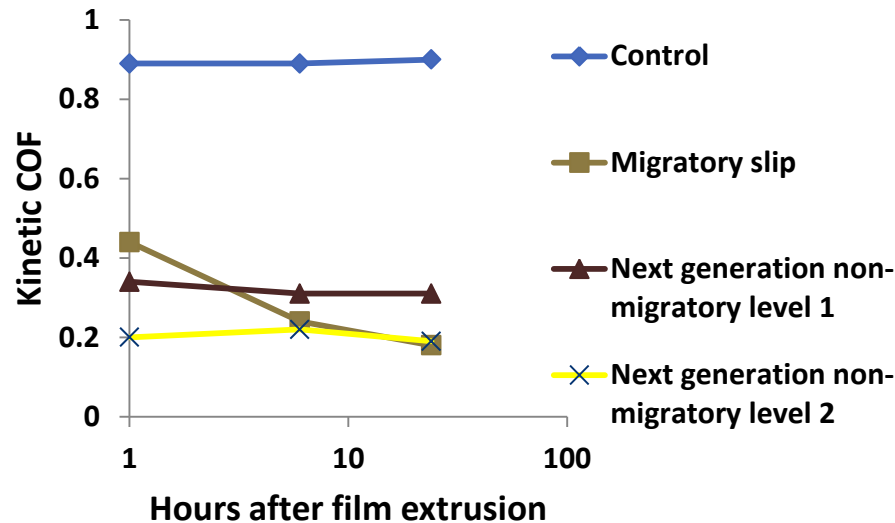
- Additives start as a homogeneous distribution in polymer
- With time migratory additives cover the surface of film
- Non-migratory additives do not migrate and COF values do not change with time

Slip performance in monolayer LDPE film



- Films were 1 mil in thickness and produced using 2 MFR LDPE
- Typical non-migratory slip agents did not reach 0.2 COF

New formulation for slip in monolayer film

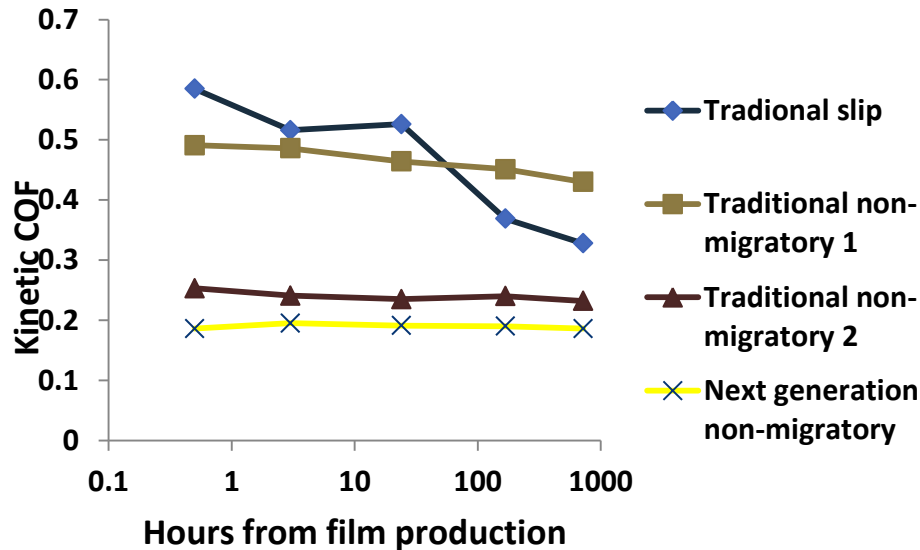


- Films were 1 mil in thickness and produced using 2 MFR LDPE
- The next generation non-migratory product achieves $\text{COF} < 0.2$

Multi-layer film work

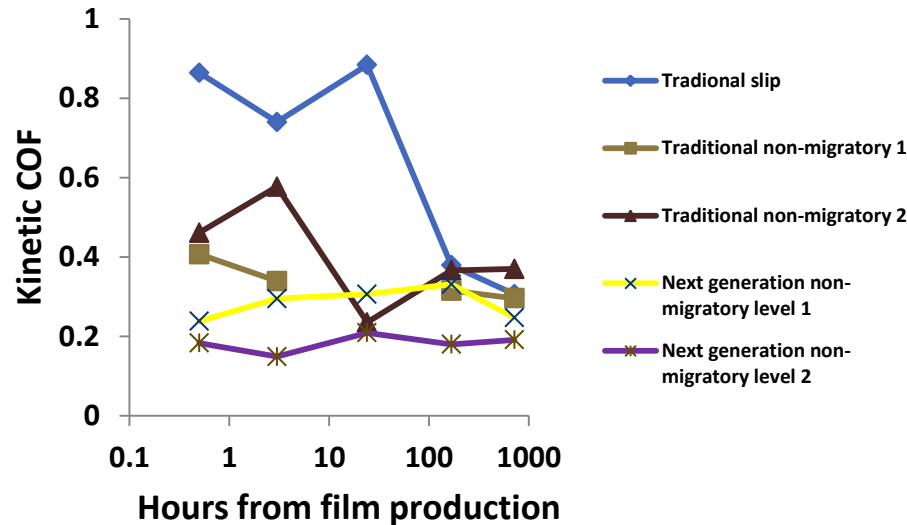
- **Three layer films**
 - Sealant layer metallocene polyethylene (m-PE) 1.4 MFR / 0.916 density
 - Core layer 70% h-LLDPE 0.9 MFR, 0.918 density / 30% LDPE 2.1 MFR, 0.92 density
 - Outer layer composition same as core layer
- **m-PE contains PPA, other resins have base antioxidant**
- **One mil total thickness with 15:70:15 layer ratios**

Slip performance in multi-layer films



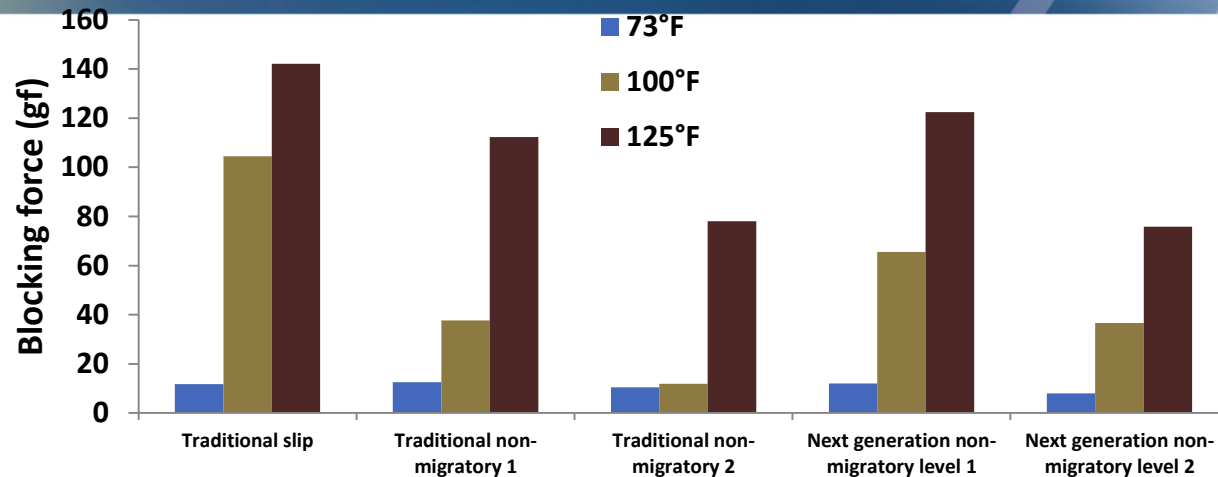
- Performance in LDPE / LLDPE outer layer
- Next generation non-migratory product achieves COF levels below 0.2

Slip performance in multi-layer films



- Performance in m-PE sealant layer
- Next generation non-migratory product achieves COF levels below 0.2, however higher levels are required with the sealant resins versus LDPE / LLDPE resins
- Greater variation in COF is observed in m-PE layer

Blocking performance in multi-layer films



- Performance in LDPE / LLDPE skin layer
- Traditional slip and some traditional non-migratory products require the presence of antiblock
- Next generation non-migratory product has equal or better performance as compared to traditional slip with antiblock

Conclusions

- Traditional slip agents require time for development of slip properties
- Traditional non-migratory slip agents act instantaneously but typically have $\text{COF} > 0.2$
- Next generation non-migratory product shows consistent COF over time and achieves $\text{COF} < 0.2$
- Next generation non-migratory product works in LDPE, LLDPE, and sealant layers like m-PE
- Next generation non-migratory product outperforms traditional non-migratory slip agents in slip and blocking properties

Acknowledgements

- Techmer PM laboratory and personnel
- Tappi conference committee
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