2nd World Congress on Polymer Science and Engineering, Barcelona, May 8-9, 2017

Fundamental Understanding of Scratch & Mar Behavior of Polymers

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BACKGROUND

- Polymeric systems are extensively used in a wide variety of applications
- Scratch and mar damages dramatically decrease surface quality
- Objective: Characterize scratch and mar damages on polymeric materials and thin films using experimental, numerical, and psychophysical tools.

EXPERIMENTAL

Slip Agent

- 20% Talc-Filled TPO
- Neat & Modified



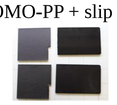
Gloss

- 20% Talc-Filled TPO
- Standard & High-Gloss



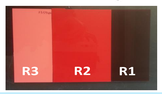
Texture

- **A:** HOMO-PP + talc
- **B:** HOMO-PP + slip agent



Color/Brightness

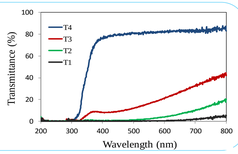
- Polycarbonate
- 3 colors / 3 brightness



Transparency

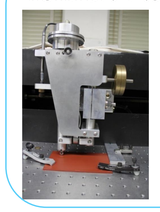
- Polycarbonate
- 4 transparency levels





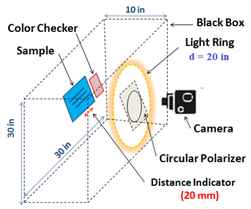
Scratch & Mar Tests and Observation

ASTM D7027-05 /ISO 19252:0







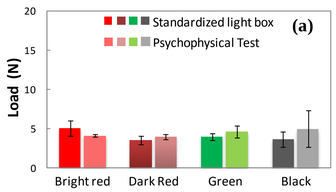


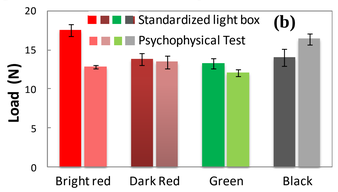


RESULTS AND DISCUSSION

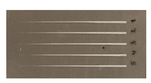
Scratch Visibility Resistance

- Slip agent-modified surfaces have improved scratch visibility resistance

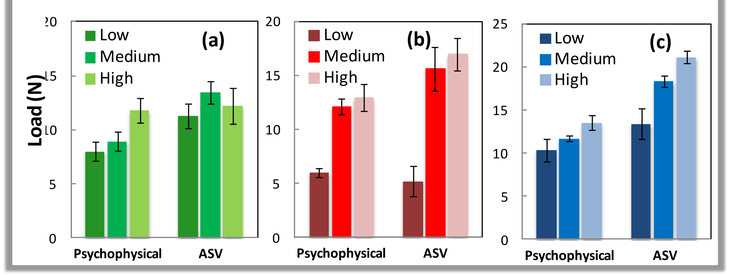




- Scratch visibility resistance decreases with dark, more transparent, and green surfaces

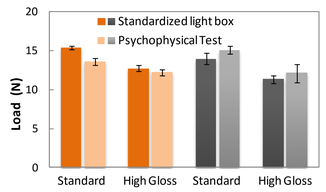


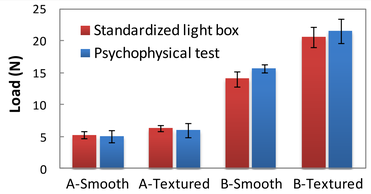




RESULTS AND DISCUSSION

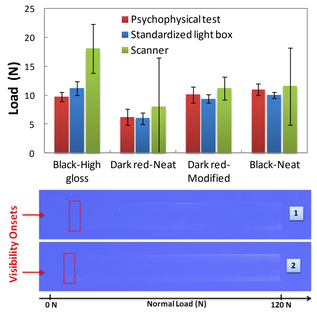
- Scratch visibility resistance slightly decreased on surfaces with higher gloss due to light reflection.
- Texture hided scratch visibility onset and improved scratch visibility resistance.

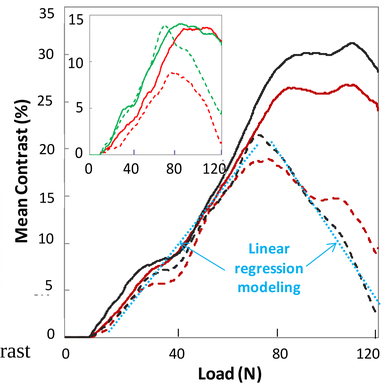




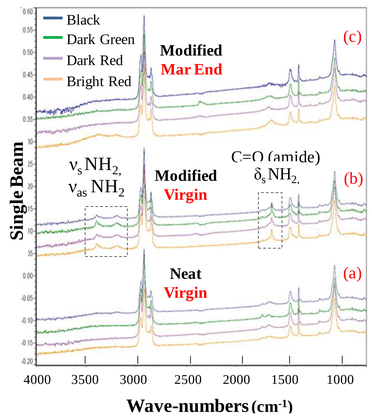
Mar Visibility Resistance

- Results obtained with the new methodology are more self-consistent and consistent with the human observation.
- Visibility onset cannot be used for consistent mar quantification
- Overall mar visibility is an alternative meaningful parameter
- Low mar visibility resistance is associated with a peak in the contrast curve.

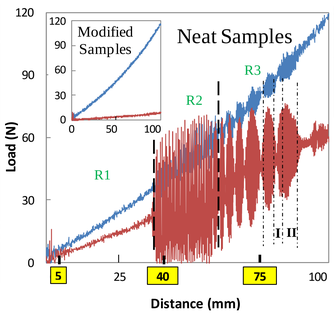


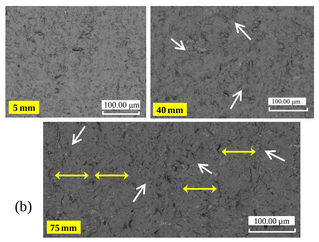


- **ATR-FTIR:** Mar eliminated slip agent from the surface increasing contrast

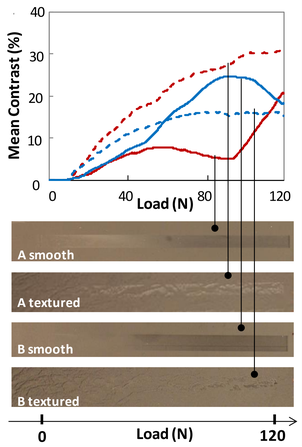


- High-friction neat samples have higher tangential load with severe fluctuations indicating the occurrence of stick-slip motion.



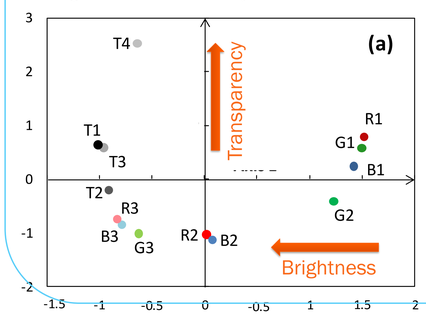


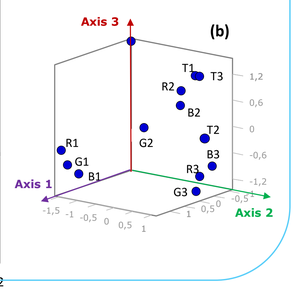
- Mar visibility resistance is higher on textured surfaces.
- Again higher contrast change is associated with higher visibility



MDS ANALYSIS

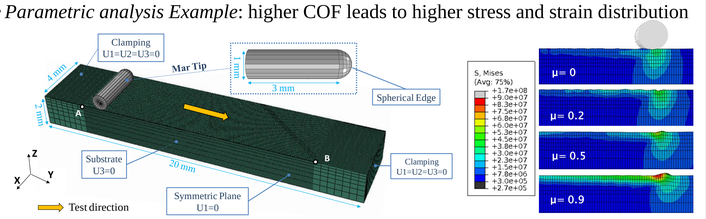
- *Multidimensional scaling (MDS):* statistical method unveils data "hidden dimensions" and visually displays the most important relationships.
- Mar visibility resistance decreases with dark, less transparent, green surfaces
- Brightness, transparency and color have a decreasing level of impact on mar



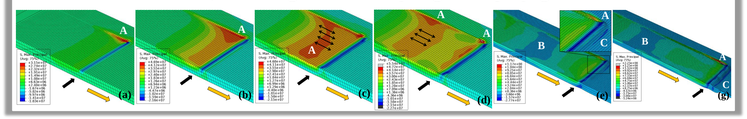


FEM MODELING

- FEM model is used to establish a relationship between constitutive and surface **properties** & scratch/mar-induced deformation **mechanisms** through **surface analysis**
- *Parametric analysis Example*: higher COF leads to higher stress and strain distribution

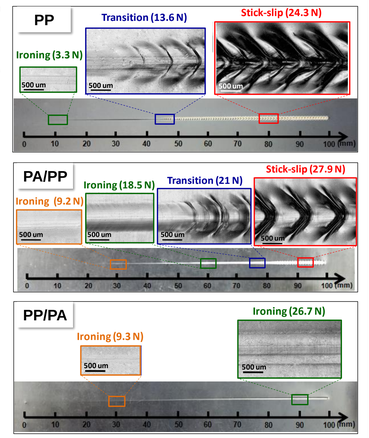


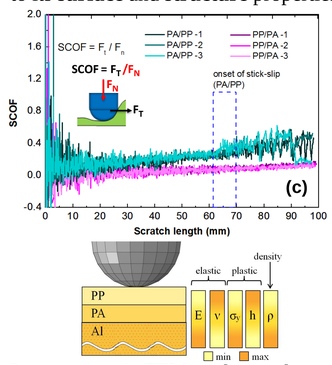
- As mar load increases, stress is generated at tip edge then propagates to inner mar area



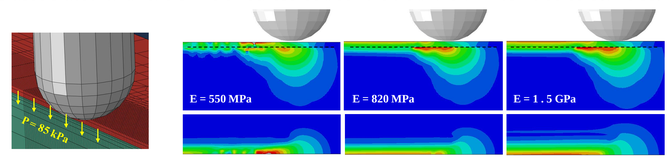
THIN FILMS

- Scratch behavior on PP/PA and PA/PP laminates was also investigated.
- PP/PA has better scratch resistance due to its **surface** and **structure** properties

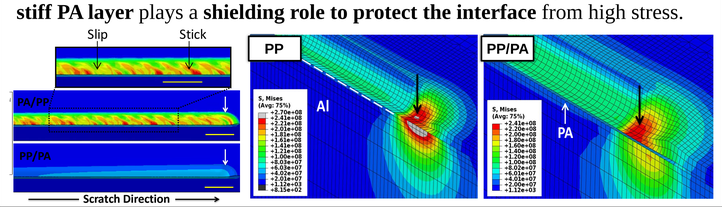




- In a parametric FEM study, we demonstrated that **higher** film scratch resistance is associated with the **shift of stress concentration from interface to surface**.



- FEM analysis shows that **PP layer absorbs** the scratch energy while **hard** and **stiff PA layer** plays a **shielding role to protect the interface** from high stress.



ACKNOLEDGEMENT

سابك sabic · Avery Dennison · Inspired Brands. Intelligent Works. · TEEE · PTC Polymer Technology Center · Advanced Composites · High Performance Research Computing A Resource for Research and Discovery · SMS

Publications