Industry Day Theme # Emerging Nano and Advanced Materials

Polyurethane Nanocomposite Films and Nylon Fabric Based Multi-Layered Laminates with High Helium Gas barrier & Weather Resistance: A potential material for aerostat

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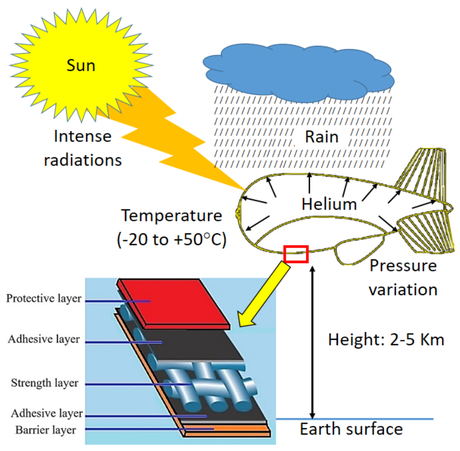
Abstract

- This study mainly focused on development multi-layered laminates for aerostat envelop
- Several PU nanocomposite (PUNC) films (loaded with organoclay, functionalized graphene, UV shielding nanopowder) having high gas barrier and weather resistance were prepared
- These (PUNC) films were laminated on a Nylon fabric in various combinations
- Performance of the laminated structures was evaluated after exposure under accelerated artificial weathering
- The PUNC based all laminates performed much better than the control sample

Introduction

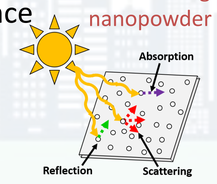
Aerostat is a lighter-than-air (LTA) system typically lifted using helium gas and tethered using a mooring system operated from a fixed location. It has different applications in defense (military surveillance, warfare control etc).



Main requirements

- Excellent weather resistance
- High helium gas barrier
- Light weight
- High flexibility
- Long service life

Mechanism of UV shielding nanopowder



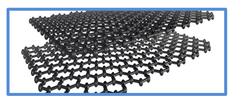
Main challenges with conventional laminates

- Delamination tendency
- Low flexibility

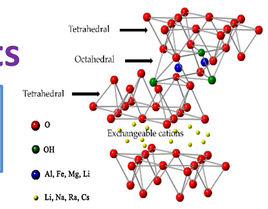
Approaches/Probable solutions

- All-polyurethane based system
- ⇧Gas barrier: Organoclay, f-Graphene
- ⇧Weather resistance: UV shielding nanopowder, organic UV additives (UVA, Antioxidant, HALS)
- PUNC films/Nylon 6,6, fabric laminates

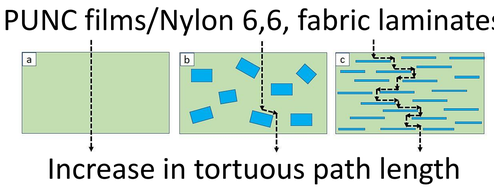
Nanoplatelets



Graphene



Nanoclay



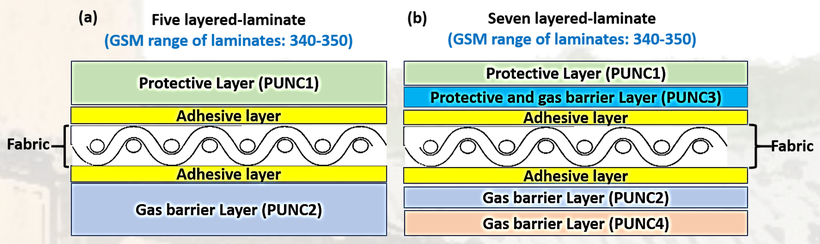
Increase in tortuous path length

Materials and Methods

Materials: TPU, Nylon 6,6 fabric, nanoplatelets (organoclay and f-Graphene), UV additives (organic and nanoparticles) and PU based adhesive

Methods:

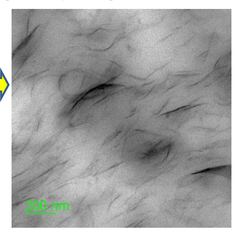
1. PU Nanocomposite (PUNC) preparation
2. PUNC based Film preparation
3. Preparation of PU based adhesive formulation
4. Preparation of multi-layered laminates
5. Exposure under accelerated artificial weathering

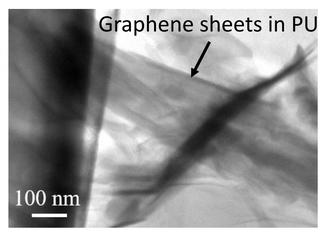


Result

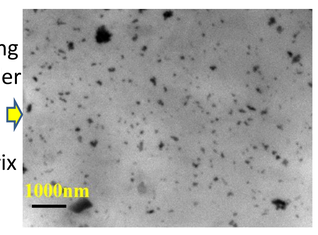
TEM Analysis (Dispersion of nanomaterials in PU matrix)

Nanoclay platelets intercalated/ exfoliated in PU matrix

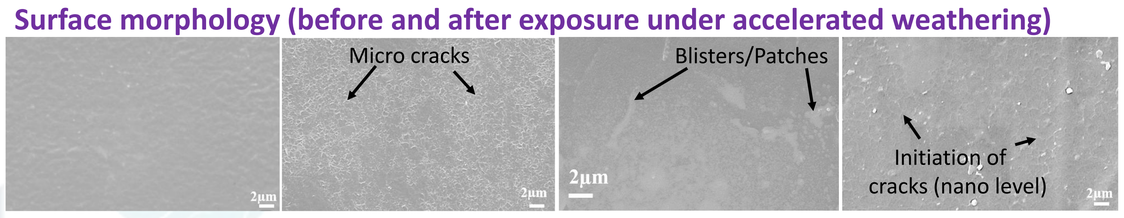




UV shielding nanopowder dispersed uniformly in PU matrix

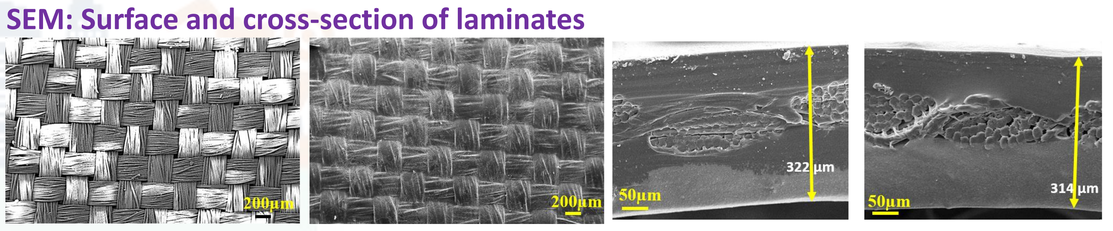


Surface morphology (before and after exposure under accelerated weathering)



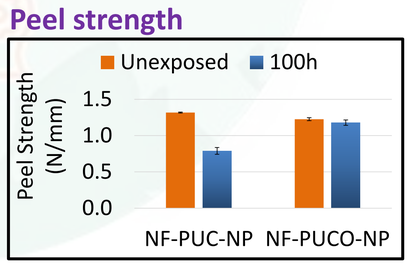
Neat PU (Unexposed) | Neat PU (300h exposed) | P/G-NC (300h exposed) | P/U-NC (300h exposed)

SEM: Surface and cross-section of laminates

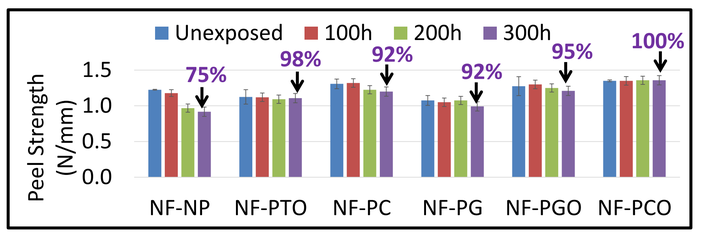


Fabric surface (Uncoated) | Uniformly adhesive coated fabric | Cross-section five layered laminate | Cross-section seven layered laminate

Peel strength

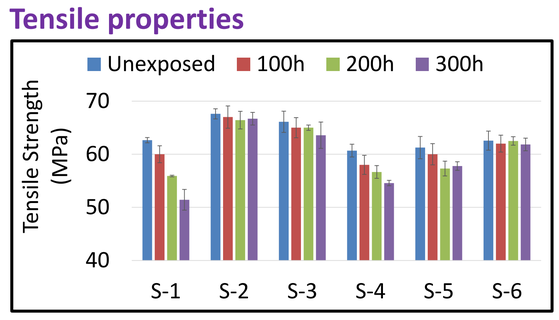


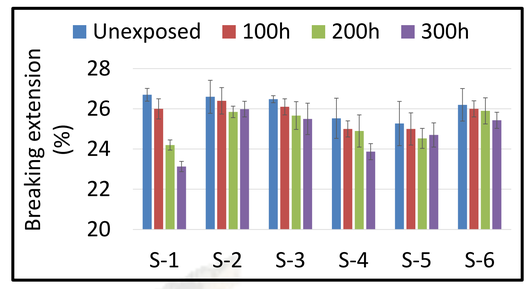
Effect of UV additives in adhesive



Effect of different fillers in PU matrix

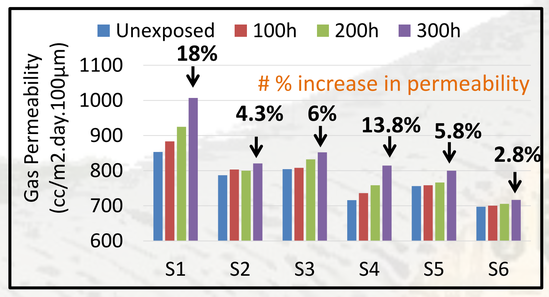
Tensile properties





Retention in tensile properties significantly improved for PUNC film based laminates compared to control one

Gas barrier property



Retention in gas barrier property significantly improved for PUNC film based laminates compared to control one

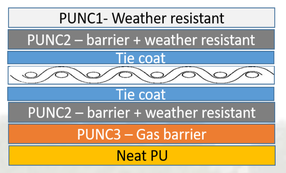
Industrial trial (Hot-melt + Sol. Coating)

Base Fabric:

GSM: 230
Fibre: Polyester

Coated fabric:

Total GSM: 545
Thickness: 518 µm
Helium gas permeability: 230 cc/m².day



Coating trial was done at Kusumgar Corporates Pvt. Ltd.
Exposure under accelerated artificial weathering is in progress

Conclusions

- Gas barrier property of PU film increased significantly: with organoclay 40% and with f-Graphene 30% reduction in helium gas permeability
- Significant improvement in weather resistance by a synergistic effect of calcinated UV shielding nanopowder and organic UV additives
- PU based UV adhesive performed well in presence of UV additives
- All PUNC based laminates showed better performance (retention in tensile properties, tear strength, peel strength and gas barrier) then control sample
- Among laminates best performance: S-2 (Five layered) and S-6 (Seven layered)

Industrial Significance

The PUNC films based laminates (especially S-2 and S-6) have a good potential to be used in the outer envelope (Hull) of aerostat

Technology Readiness Level

- All lab scale optimization (Film/Laminate preparation and performance analysis) has been completed
- Planning for pilot scale production of PUNC based films and laminates (Interested for Industrial collaboration)

References

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Acknowledgement

1. Aerial Delivery Research and Development Establishment (ADRDE), Defence Research and Development Organisation (DRDO), Govt. of India.
2. Central Research Facility (CRF), IIT Delhi
3. Nano Research Facility (NRF), IIT Delhi

Department of Textile Technology