Functionalising textiles using environmental friendly techniques

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i-sup 2008
Bruges, April 23-25
Outline:
- Introduction
- Hot melt
- UV coating
- Plasma treatment
- Summary
Introduction
Introduction

Increasing importance of textile functionalisation/finishing
Introduction

- Several traditional methods for textile functionalisation
  - E.g. immersion, Mayer bar,…
- But:
  - Solvent-based: environmental problems
  - Water-based: drying → energy requirement
  - Typical numbers:
    - 1 kg of textile requires 50 litre of water
    - Temperature: 50 – 70 °C
    - Energy use in textile industry: 60% is for heating/drying

→ Clear need for alternatives
Introduction

- Highlight three alternatives:
  - Hot melt
  - UV Coating
  - Plasma treatment

- Not included: powder coating, extrusion coating, …
Hot melt

www.robatech.com
Basics

- Hot melt:
  - 100% system (granulates, blocks,...)
  - Melting of the polymer
  - Application as melt
  - Solidifying → Coating

- Two main groups (curing based):
  - Thermoplastic hot melts:
    - Solidifying via cooling
    - Materials: PE, PP, PES, PA, EVA, TPU, silicone
  - Reactive hot melts:
    - Solidifying via cooling + drying or UV irradiation
    - Materials: PU, APAO’s

www.robatech.com
Important properties/functionalities:
- Fire retardant
- Antimicrobial
- Fibre & pile binding
- Delamination
- Tear and tensile strength
- Dimensional stability (domestic washing and drying)
- ...

No new functionalities
## Hot melt ↔ other coatings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Water based paste</th>
<th>Solvent based paste</th>
<th>Powder coating</th>
<th>Hot melt coating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water</strong></td>
<td>Yes (40 – 60%)</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Solvent</strong></td>
<td>No</td>
<td>Yes (50 -70 % )</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Emission</strong></td>
<td>Yes (in oven)</td>
<td>Yes (in oven) + hood compulsory for solvent fumes</td>
<td>No</td>
<td>Potentially at high temp. with reactive PU</td>
</tr>
<tr>
<td><strong>Energy use</strong></td>
<td>High (water evaporation)</td>
<td>Relatively high (solvent evaporation)</td>
<td>Lower (powder melting)</td>
<td>Even lower (hot melt polymer melting)</td>
</tr>
<tr>
<td><strong>Waste</strong></td>
<td>Paste</td>
<td>Solvent containing paste</td>
<td>Negligible – powders can be re-used</td>
<td>Negligible – polymer can be re-used (except. reactive polymer)</td>
</tr>
</tbody>
</table>

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Comparison: water based dispersion vs. hot melt

Process assumptions:
- Textile substrate weight: 150g/m²
- Dry coating weight: 30g/m²
- Line speed = 30m/min
- Width = 1.80m
- Water based coating:
  - 50% water in formulation
  - Energy: for water evaporation
- Hot melt coating:
  - PO polymer, melt temperature 160°C
  - Energy: heating and melting of the polymer

Following results:
- Standard coating: 210 kJ/m²
- Hot melt coating: 56 kJ/m²

Hot melt / standard ≈ 27%
Advantages and disadvantages

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Industrial use</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High line speed</td>
<td>• Limited flexibility for functional additives</td>
<td>• Well-integrated for lamination</td>
</tr>
<tr>
<td>• Short production lines (no oven)</td>
<td>• Tactile properties</td>
<td>• R&amp;D for (functionalised) coating via hot melt</td>
</tr>
<tr>
<td>• No solvents (safety)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• No auxiliary products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• No specific preparation to produce coating paste (↔ conventional coating via “paste” or “foam”)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
UV coating
Principle

IR source

UV source

UV

Textile substrate

Coating application

Curing
UV coating formulation

- Oligomers:
  - Adhesion, flexibility, shrinkage, ...
- Monomers:
  - Monofunctional:
    - Flexibility, reactivity, ...
  - Multifunctional:
    - Adhesion, shrinkage, ...
- Photo initiators
- Thickeners/ thinners
- Additives
Process parameters:

- **UV source:**
  - Type (Hg, doping with Fe, Ga, ...)
  - Power (W/cm²)
- Distance between UV source - textile
- Line speed
- Heat production
Textile application field

**Materials**
- Furnishing fabrics
- Mattress ticking
- Curtains
- Wall covering

**Properties**
- Abrasion resistance
- Light fastness
- Comfort properties
- Tactile properties
- Colour fastness

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Energy use: UV ↔ water based

- **Comparison:** water based dispersion vs. UV coating (100%)
- **Process assumptions:**
  - Dry coating weight: 30g/m²
  - Textile weight: 150g/m²
  - Line speed = 30m/min
  - Width = 1.80m
  - Water based coating:
    - 50% water in formulation
    - Energy: for water evaporation
  - UV coating:
    - Energy: UV lamp
- **Following results:**
  - Standard coating: 210 kJ/m²
  - UV coating: 91 kJ/m²
  \[ \text{UV / standard} \approx 43\% \]
## Advantages and Disadvantages

### Advantages
- Solvent free → reduced emissions
- High line speed
- Coating quality
- Reduced water use

### Disadvantages
- Additives (e.g. pigments) can interfere with UV light, reducing the curing
- Price of coating formulation
- Adhesion

### Industrial use
- R&D efforts for textile applications
Plasma treatment
Plasma treatment

![Diagram of plasma treatment process]

- Plasma source
- Plasma
- Substrate
Plasma coating

- Plasma + Precursor (chosen according to the desired properties)
- Coating possible → permanent change of the surface properties
- Crucial: interaction between precursor and plasma
Possible textile applications:
- Oleophobic
- Hydrophobic
- Hydrophilic
- Primer layer
- Anti-fouling
- Anti-microbial
- Biocompatibility
- ...

Possible with traditional techniques → why use plasma?
Example: antibacterial coating

- Atmospheric plasma deposition of antibacterial agent
- Surface analysis:
  - Uniform layer
  - Coating thickness: 2-5 nm
- Functional analysis:
  - Good antibacterial response
- Durability:
  - Good abrasion resistance

→ Functional, durable effect with minimal add-on possible
Energy use: oleophobic process for PES

Comparison of environmental impact:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>GWP (kg CO2)</th>
<th>AP (g eq SO2)</th>
<th>POPC (g C2H4)</th>
<th>EU (g PO43-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma</td>
<td>0.4</td>
<td>1.22</td>
<td>0.19</td>
<td>0.26</td>
</tr>
<tr>
<td>Traditional</td>
<td>1.67</td>
<td>2.36</td>
<td>2.81</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Legend:
- GWP: Global Warming Potential, i.e. CO₂ emission
- AP: Acidification of ground, air, water
- POPC: Photochemical ozone creation, i.e. contribution to ozone formation
- EU: Eutrophication

LCA Analysis of energy use:
- Plasma process = 1/3 of traditional process

Source: www.acteco.org
Advantages and disadvantages

Advantages

- No influence on the bulk properties
- No influence on “hand”
- Functionalisation “within” substrate
- Energy saving: no water involved
- Reduced ecological impact

Disadvantages

- Limited add-on
- Treatment width
- Maximum line speed

Industrial use

- Sporadic use as pre-treatment step (plasma activation)
- R&D efforts plasma coating
Conclusions

Textile finishing:
- Replacing traditional water and solvent based coatings
- Hot melt – UV coating – Plasma treatment

All have their specific (dis)advantages, generally:
- Disadvantages:
  - Drawback coating characteristics (e.g. stiffness, thickness,…)
  - Limited throughput
- Advantages:
  - Minimising environmental impact
  - Strongly reduced energy use

Technologies (becoming) ready for industrialisation