**Introduction**

Electrophotographic digital technology is used in high quality print engines to transfer electrostatically-charged toner onto substrates. The print quality of such systems is a complex function of the interactions of the individual components. Despite this complexity, through understanding of print system mechanisms, design criteria can be established for each constituent part for performance optimisation. In this paper, the requirements and materials development for one component, the transfer roller, will be discussed.

**Typical Electrophotographic Print Engine**

- Laser discharging
- Corona charging
- Toner reservoir
- Transfer roll
- Photo conductor plate
- Print media

**Transfer Roller Key Properties**

- Stable dielectric properties throughout the service life ensures optimal print quality and toner transfer efficiency.
- Smooth low surface energy, provides crisp image transfer.
- Optimised mechanical properties to maximise service life (e.g. hardness and tensile strength).
- Resistant to both chemical and environmental attack.
- Cost.

**Comparison of Elastomer Performance**

The advantages and disadvantages of some elastomers commonly used in transfer rolls are shown in the table below:

<table>
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<tr>
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<th>Urethane</th>
<th>Organic Rubber</th>
<th>Silicone</th>
<th>Fluorosilicone</th>
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<tr>
<td>Image transfer</td>
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<td>Service Life</td>
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<td>Toner release (surface energy)</td>
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<td>Mechanical strength</td>
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<td>Chemical resistance</td>
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<td>Wear resistance</td>
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<td>Customisation</td>
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</table>

Polyurethane was chosen for this study as it provides a strong balance of properties, ease of customisation and a potential cost benefit.

**Polyurethane Chemistry**

Polyurethanes are created through the reaction of an isocyanate (hard segment, depicted in orange) with a polyol (soft segment, depicted in green) and can be customised to suit the application. The soft segment provides flexibility, while the hard segment provides mechanical strength. Furthermore, the choice of polyol will impact the hardness, chemical resistance, and other properties of the urethane.

Within this study the following were adjusted:

- Type of isocyanate and polyol
- Amount of hard segment chain extender (short chain diol)
- Type and level of conductive additive

**Effect of formulation on Key Properties**

**Electrical Resistivity**

Unfilled PU is an insulator so conductive additive agents are required to impart conductivity. Once a certain level of agents are reached (percolation), the conductivity stabilises for small changes in filler loading and additive dispersion.

**Hardness**

Proprietary conductive additives and the chain extender were found to affect hardness. The chain extender influences hardness by altering the ratio of hard and soft segments in the PU.

**Chemical Resistance**

Through changing the isocyanate and polyol type the chemical and environmental resistance of the roller can be adapted. Through selecting the right combinations, two potential formulations were identified that offered excellent resistance to Toner and environmental attack.

**Mechanical Strength**

For the chosen formulation, adjusting the concentration of conductive agents was found to have little affect on tensile strength. Varying the chain extender concentration was found to affect tensile strength.

**Conclusions**

Polyurethanes uniquely offer a range of options to optimise the characteristics of electrophotography transfer rollers. This paper has shown how these characteristics can be optimised through the correct selection of the base monomers, the conductive agents and other compounding additives. By using a designed experiment, Fenner Precision has optimised the formulation to meet the requirements of an electrophotography transfer roller.

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