The Effect of Plasma Functionalisation on Nanomaterial Fillers in Elastomeric Compounds

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  • What we do
  • HDPlas® Plasma Functionalisation Process
  • Nanomaterial selection

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Plasma Functionalisation

RAW MATERIALS
- GRAPHENE
- CARBON NANOtUBES (CNTs)
- OTHER NANOMATERIAL

CHEMISTRY
- O₂
- COOH
- NH₃
- F
- Other...

LEVEL
Degree of functionalisation

INTERMEDIATES
- INKS; DISPERSIONS; ETC
- POLYMERS; COMPOSITES; COATINGS; ETC

SURFACE FUNCTIONALISATION

END USES
- TRANSPORTATION; ENERGY; OFFSHORE; ELECTRONICS; PACKAGING; CONSTRUCTION; MEDICAL...

HT60 Plasma Reactor

HT200 Plasma Reactor
Plasma Functionalisation

Haydale run a low temperature, low pressure plasma.

A process gas is flowed into a rotating vacuum chamber which is pre-loaded with the desired nanomaterial.

An electrical potential is applied and the gas is dissociated into its component parts. This process yields a distinctive glow.

The dissociated ions bombard the nanomaterial, producing chemical groups at the surface.

These functional groups then improve the properties of the nanomaterials.
Dispersion Improvements

- Unfilled Epoxy
- Epoxy + Untreated material
- Epoxy + HDPlas™ material
Haydale does not manufacture nanomaterials, instead we have multiple sources and can handle a range of different material morphologies.
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Addition of HDPlas® MWCNT to HNBR and VMQ

- HDPlas® MWCNTs were added into standard VMQ and HNBR elastomeric compounds
- A range of functionalisations were trialled to evaluate the effect of functionalisation on physical properties
- Functionalisation #16 was shown to have the most interesting stress/strain properties
- Functionalisation #16 was therefore chosen for further CB substitution trials
Substitution of CB with HDPlas® MWCNT in HNBR

• HDPlas® MWCNT-16 was chosen for further CB substitution trials in HNBR

• Standard CB was substituted out for MWCNT-16, maintaining a hardness of 90 shore

• This substitution method realised the full potential of HDPlas® MWCNTs

✓ Increase in modulus of >40%
✓ Increase in elongation at break of >20%
✓ Increase in tear strength of >30%
✓ Small increase in tensile strength
✓ Small decrease in specific gravity
✓ Increase in electrical conductivity

### Surface Resistivity

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<tr>
<td>Control</td>
<td>Resistive</td>
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<td>Trial 16.1</td>
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<tr>
<td>Trial 16.3</td>
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Substituting CB with HDPlas® MWCNT in HNBR

- By substituting standard CB for MWCNT-16, the dynamic properties of 90 shore HNBR also improved
- Increase in Tanδ of 15-35% at a range of frequencies
- Increase in Tanδ of up to 6% at 0°C
- Increase in Tanδ of up to 15% at 60°C
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• **Plasma Functionalised rCB Work in Elastomers**
Early results have been obtained for plasma treated recovered CBs.

The two rCBs were treated with 3 different functionalities, as a consequence, all functionalisations increased the torque value compared to untreated rCB on MDR.

This indicates that there has been an increase in reinforcement, or cross-link density, as a result of plasma functionalisation.

These results are the first generated, from the first batch of functionalised materials that have been incorporated into rubber.
Plasma Functionalisation of rCBs

- All three plasma functionalisations have a positive effect on the ultimate tensile strength of natural rubber, compared to untreated rCB.
- Limited effect on the elongation at break.
Plasma Functionalisation of rCBs

- Plasma functionalisation shows to have a significant effect on the low-extension modulus, compared to untreated rCB and standard carbon black.
- This supports the increase in the max torque (MH) seen on the MDRs.
- Changes in physical properties show that plasma functionalisation can positively affect the surface of rCBs, depending on functionalisation type.
Conclusions

• Plasma functionalised nanomaterials such as MWCNT can be used to improve electrical, physical and dynamic properties of elastomers

• Plasma functionalisation can be used to alter the surface characteristics of rCBs to improve physical properties of elastomers
Thanks to our collaborators in these projects
Thank you for Listening

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