



Nitrocellulose Processing in a Flammable Solvent: Designing a Safer Process

7th Nitrocellulose Symposium

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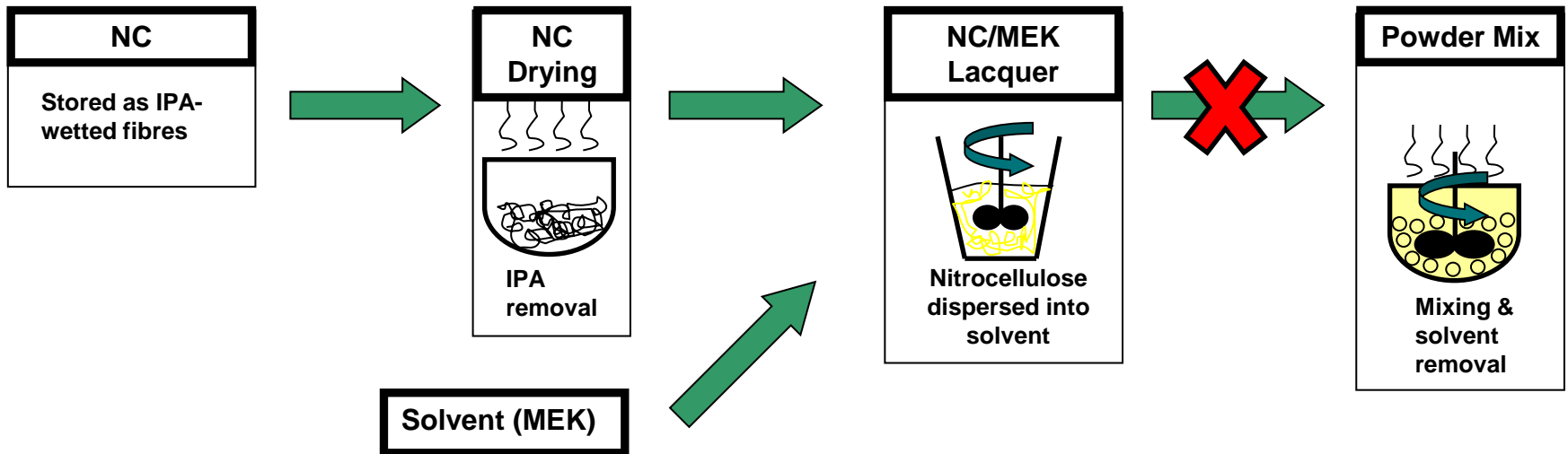
Explosive Materials & Initiation Science

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NC/MEK Lacquer Process

- AWE routinely produces an 'industrial' NC/MEK lacquer
- Historical process performed several thousand times over several decades





Dry NC Properties

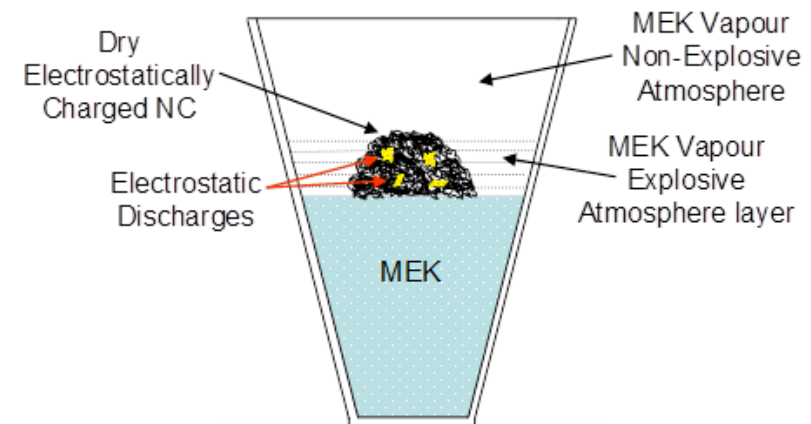
- NC is a highly resistive material with a similar volumetric resistivity to nylon ($10^{14} \Omega \text{ cm}$)
- NC is judged to be similar to nylon and cellulose acetate which are strongly positive in the triboelectric series
- Drying conditions (49 hours at 80°C) expected to have produced a very dry, highly charged NC sample
 - The extent to which NC is dried is expected to affect the magnitude of charge that can be acquired on the surface of the fibres
- Packing dry NC in resistive polyethylene bags and manual handling are significant charging mechanisms
 - Positively charged NC with an electrical potential of tens of kV!

MEK ignition

- MEK is a highly conductive liquid with an electrical conductivity similar to drinking water, dense vapour and a (very low) minimum ignition energy of 0.53 mJ
- Electrostatic discharges in the NC with energies between 0.5 - 1 mJ would be sufficient to ignite flammable MEK vapour/air mixtures (1.8 to 11.5% MEK vapour in air)
 - The likelihood of a sufficiently energetic ESD event being exactly co-located and coincident with a flammable region of MEK vapour/air was judged to be very low
 - This low probability gives a possible explanation of why this event had not occurred previously

NC Processing Fire

- A fire occurred in August 2010 during the routine preparation of NC/MEK lacquer
 - NC was dried at 80°C
 - Ignition occurred and fire spread to combustible materials
- Independent internal investigations as well as investigation by the HSE* were undertaken:
 - “Most likely source of ignition was an electrostatic discharge from highly charged, dry NC”
- AWE was prosecuted & fined



* Health & Safety Executive



Process Safety Improvement

- AWE takes health & safety responsibilities extremely seriously
- We have worked very hard to implement the recommendations from the independent internal investigation & those made by the HSE



Process Improvements

- Improved training & awareness of hazards
- Correctly specified PPE (e.g. Nomex overalls)
- Facility provides a fully conductive regime
 - Lots of stainless steel!
 - Charge accumulation eliminated
 - Static dissipative bags, no polyethylene drums!
- NC/MEK lacquer is prepared and handled remotely where possible
- NC no longer dried other than for analysis
 - Conductive wetting agent (IPA or water) prevents charge build-up
 - Work undertaken to demonstrate minimal implications of adding wetting agent to the lacquer
- An indirect (viscosity) method was successfully developed to quantify the concentration of 'dry NC' in the lacquer

Process Improvement: Lacquer Preparation



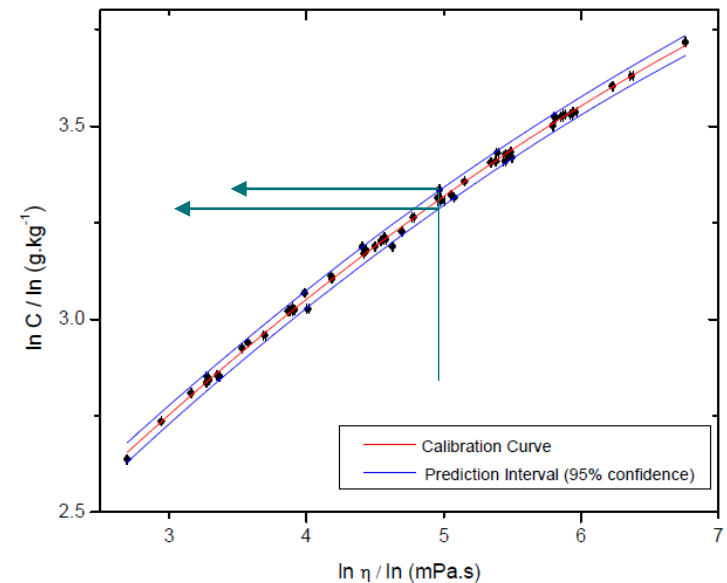
Fume
Cupboard



Bi-axial
Mixer

Process Improvement: Lacquer NC Content

- Lacquer viscosity was shown to be an effective surrogate for NC concentration
- Predicted NC concentration 95% confidence levels were determined
- Viscosity gives rise to a relatively narrow range of possible NC concentrations ($\pm 3\%$)



Process Improvement: Remote Handling



Control
Desk



Solvent Paste
Mixing



Conclusions

- A fire broke out at AWE in 2010 when preparing a lacquer from dry NC & MEK
- The most likely source of ignition was judged to be electrostatic discharge from charged dry NC fibres
- The facilities were extensively refurbished to provide a conductive regime & prevent charge accumulation
- The process has been overhauled:
 - Eliminate drying of NC
 - All materials handled remotely wherever possible
- Lacquer viscosity is used to indirectly determine the concentration of NC in the lacquer