



Liquid Scintillator Composition and QC (WBS 2.2.1.6, 2.2.2.6, 2.2.3.6, 2.2.4.2.4, 2.2.4.3.4)

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Liquid Scintillator: Composition

By weight:

- Mineral oil – 94.4%
- Pseudocumene (PC) – 5.5 %
- PPO – 0.1 %
- Bis-MSB – 0.002 %
- Stadis 425 – 0.0003%
- Tocopherol (Vitamin E) – 0.001 %



Mineral Oil

- Long hydrocarbon chains, mostly saturated
 - Some have aromatic rings
- Paraffin balls
 - Physical process → induced by low temperatures
 - Melting occurs as temperature increases
 - Tests have been performed at Fermilab and Indiana University
 - ISO tanks → heated to avoid problems in the winter



Mineral Oil

- Water - <30 ppm by manufacturer's specifications
 - Manufacturer \rightarrow water will make mineral oil cloudy
 - NOvA tests performed by Chuck Bower at Indiana University :
 - Add water to liquid scintillator \rightarrow 5 mL water in 100 mL liquid scintillator
 - Water settles down without any effect on light yield
 - Undesirable: It will take out detector space



Mineral Oil

- QC/QA program:
 - At the vendor:
 - Check specific gravity, kinematic viscosity, water and antioxidant concentrations
 - Verify results by means of an independent testing laboratory
 - Check attenuation length
 - Commercial instrument – tintometer – Lovibond PFX 880
 - At the blending facility:
 - Check attenuation length at arrival time
 - Check attenuation length before blending into scintillator
 - All results stored in NOVA database



Pseudocumene

- 1,2,4-Trimethylbenzene = pseudocumene (PC)
- Aromatic hydrocarbon → primary scintillant
- 97-98% purity
 - 3-2% mostly trimethylbenzene isomers
- Two vendors, U.S. and China:
 - Similar characteristics



Pseudocumene

- QC/QA program:
 - At the vendor:
 - Check purity, density, color, sulfur and kinematic viscosity
 - Verify results by means of an independent testing laboratory
 - At the blending facility:
 - Check attenuation length at arrival time
 - Check attenuation length before using material
 - Take a sample for chemical analysis by GC/MS at Indiana University
 - All results stored in NOVA database



PPO

- 2,5-Diphenyloxazole = PPO
- Commonly used in plastic and liquid scintillators
 - Primary wavelength shifter
 - Maximum emission at 360-365 nm
- White powder
- High purity (>99%)
- Readily dissolved in pseudocumene



PPO

- QC/QA program:
 - At the vendor:
 - Standard testing for residue, solubility, melting point, color, odor,...
 - At Fermilab:
 - Previously done for MINOS
 - Take a sample from each batch
 - Check melting point, absorption and fluorescence spectra of toluene solutions containing specific PPO concentrations
 - Periodically check ^1H NMR and IR spectra (done at NIU)
 - All results stored in NOVA database



Bis-MSB

- 1,4-Bis(2-methylstyryl)benzene = bis-MSB
- Commonly used in plastic and liquid scintillators
 - Secondary wavelength shifter
 - Maximum emission at 420-430 nm
- Yellow crystals (flakes)
- High purity (>99%)
- Powder is readily dissolved in pseudocumene
 - Crystal is harder to dissolve



Bis-MSB

- QC/QA program:
 - At the vendor:
 - Standard testing for residue, solubility, melting point, color, odor,...
 - At Fermilab:
 - Take a sample from each batch
 - Check melting point, absorption and fluorescence spectra of toluene solutions containing specific bis-MSB concentrations
 - Periodically check ^1H NMR and IR spectra (done at NIU)
 - All results stored in NOVA database



Vitamin E

- α -Tocopherol = Vitamin E
- Common antioxidant
- Widely used in mineral oil
- Added by the vendor in its facility
- Its concentration can be checked by GC/MS or LC/UV if needed



Stadis-425

- Anti-static agent
- Commercially available
- Added to the mineral oil at the final blending stage along with the dopant/PC mixture
- Conductivity properties of the final liquid scintillator will be checked at the blending facility.



WLS – PC Mixture

- QC/QA program:
 - Before blending:
 - Checked all separate components before use
 - PC, PPO and bis-MSB
 - After blending:
 - Take a sample and add specific amount of mineral oil
 - Use sample to check attenuation length and light yield
 - Attenuation length with the tintometer
 - Light yield with the α -source test (composition)
 - All results stored in NOVA database



Liquid Scintillator

- QC/QA program:
 - Before blending:
 - Check all separate components before being used
 - Mineral oil, PC, PPO and bis-MSB, WLS-PC mixture
 - After blending:
 - Check attenuation length
 - Light yield
 - Conductivity
 - At Ash River, MN:
 - Check attenuation length of a sample taken before using liquid scintillator in tank
 - All results stored in NOVA database