Summary of Scintillation Materials for Midwest Working Group

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At BNL, we have developed techniques for loading metals, such as Gd, In, Yb, up to several %, into different scintillation solvents. The loading techniques that use carboxylic acids are quite consistent and have been studied for several years at our group. Recently we successfully prepared some initial samples of Gd-loaded scintillators. The basic chemistry does not vary much in terms of loading metals vs. different scintillation solvents, but the fine tuning to make the final detector with appropriate attenuation length, good light yield, and chemical and detector stabilities will require additional R&D. Thus it is very important to try to finalize our choice of detecting materials (desired scintillation solvent and wavelength shifters) soon, so we will have time to optimize every component in our system for precise measurement of θ_{13}.

It should be noted that we have had discussions with Ed Blucher and Mike Shaevitz about the fact that our R&D concerning preparation of suitable Gd-loaded liquid scintillators is generic in the sense that it will be applicable to any of the proposed θ_{13} experiments.

As we discussed before, the absorbance of pure PC (pseudocumene) has a rapid rise in the UV region below 400 nm; particularly at 300 nm, the attenuation length is only few cm. This cannot satisfy our requirement for light transmission, and thus chemical shifters have to be added. Unfortunately most commonly used fluors, such as PBD, PPO, MSB, POPOP… will shorten the decay time, which contradicts the idea of slow scintillation light for time-delay measurements. However there are some slow shifters that might fit our needs. For example, dimethyl naphthalene, which has τ_t = 78 ns with an absorption at 300 nm and emission at 340 nm, in principle can fit nicely with PC (absorption at 260 nm and emission at ~290 nm). This possibility will have to be studied.

Another concern is the compatibility of vessel to contain the scintillator. PC is an aggressive chemical and will attack most of the polymer materials, such as acrylic. If wave-shifting light collector are used, they might not be compatible with PC. Thus other scintillating solvents besides PC have to be studied. Among many π-electrons, ring-like molecules, PCH (phenyl cyclohexane) is a possible alternate, which is gentler in term of chemical reactivity and has similar light yields as PC (see Fig. 1). Moreover, the purified PCH has better edge below 400 nm, compared to the purified PC (see Figs. 2 & 3). It should be noted that the methods of purification are very important and work differently for different solvents. Note also that the SNO project had a consultant who is an expert on the compatibility of acrylic with many liquids. He did ASTM-type tests and prepared a table that lists the liquids that are acceptable and the many that are unacceptable. We can see if we can obtain a copy of this table.

Mixing PC with mineral oil can be another selection for scintillation materials. The general impression among researchers is that 20% PC mixed with mineral oil is safe for acrylic, such as the SNO AV, although some reports have suggested that acrylic in 40% PC is stable too. A detailed study in this aspect should be started soon. Practically there are many types of mineral oils, and they all behave differently. The light mineral oil used at *MiniBooNE* seems to fit our requirements. Yeh spoke with some colleagues in the *MiniBooNE* collaboration and have the general impression that the quality of mineral oil from industrial suppliers is not stable. The distributing company normally purchases large quantities of mineral oils from the refiners first, and then mixes them to meet the purchaser's requirements, in terms of viscosity, density, attenuation length, … etc. So it is very important to have a QC program or a team in the collaboration to verify the quality of solvents shipped from the manufacturers. At BNL, we will purchase some mineral oil, which have similar quality as *MiniBooNE*, to do some tests.

Proposed chemical works:

Various tests for different scintillation systems: pure PC, pure PCH, 20% PC/mineral oil, and 40% PC/mineral oil. Preparations of Gd-loaded liquid scintillators, at the level of ~0.1%, based on the solvent tests.

1. Stability and compatibility tests vs. acrylic or other materials of interest at both room temperature and elevated temperature (aging test, 50^{o} C for few days).
2. Light yield measurements.
3. Light attenuation measurements, with pathlengths of 10 cm and 100 cm.
4. Long-term chemical stability.
5. Decay time measurements.
6. The impacts of wavelength shifters on the performance of scintillator.

Figure 1. PC vs PCH light yield

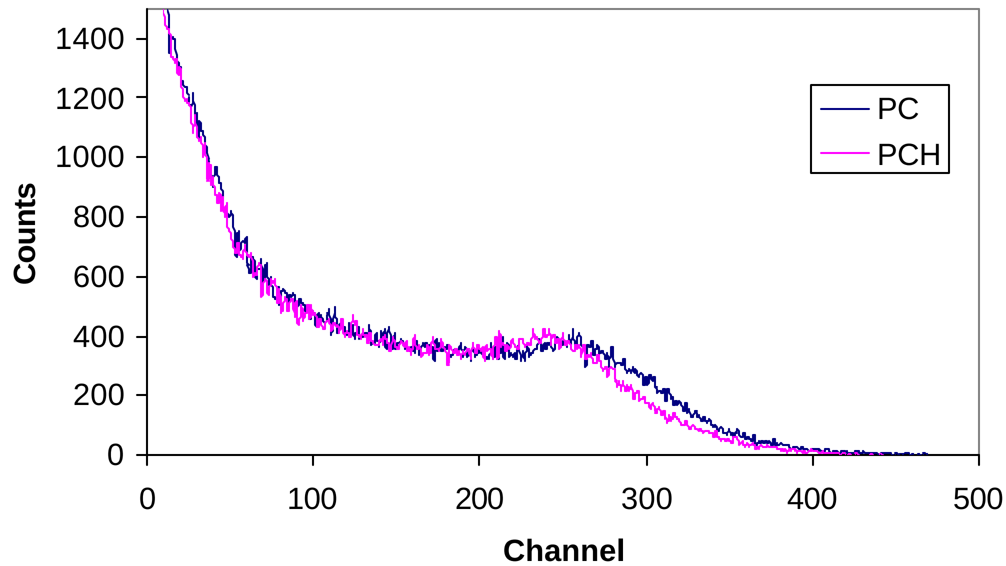

Figure 2. 10-cm UV for PCH

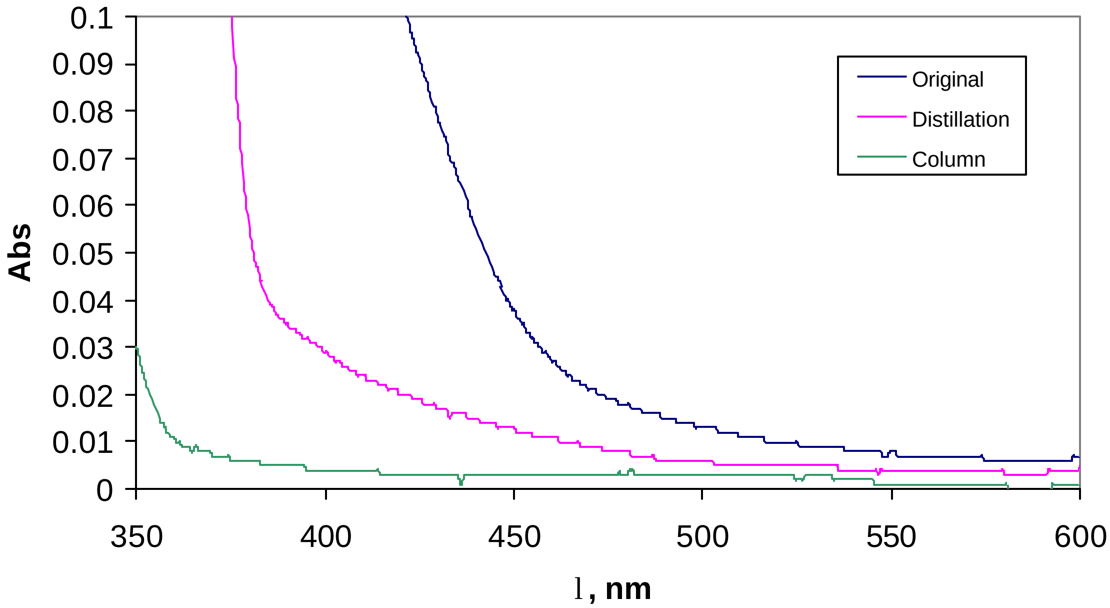

Figure 3. 10-cm UV for PC