Effect of secondary solvent on the sample load capacity of a newly designed scintillation cocktail

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HIGHLIGHTS

- **New modern scintillation cocktail**
- **Scintillation cocktail components optimization**
- **Excellent properties of sample load capacity**

MOTIVATION

Scintillation cocktails serve as a medium for transferring energy (ionizing radiation) from the sample to a form that can be processed by a LSC counter. If the activity of the sample is low, it is best to choose a cocktail that holds as much of the sample as possible and still provides maximum detection efficiency with a minimum of background pulses. This property is described by the so-called sample load capacity, i.e. the amount of sample that the scintillation cocktail is able to hold and at the same time retain all its detection properties, while remaining in the form of a homogeneous single-phase mixture. The paper describes the influence of secondary organic solvents on the performance of a newly designed scintillation cocktail. It mainly focuses on the sample load capacity of the scintillation cocktail in connection with the solvent component to be able to accept the largest possible volume of different types of samples, especially aqueous ones.

CHEMICALS

2,5-diphenyloxazole – PPO
2-(1-naftyl)-5-fenyloxazol – NPO
1,4-bis(2-methylstyryl)-benzene – MSB
Triton X-114
polyalkoxy-alkylphenylphosphate ester
butyldiglycol – BDG
di-isopropylnaphthalene – DIPN
1-methylnaphthalene – MN
diethylbenzene – DEB
dodecylbenzene – DDB
propylbenzene – PB

RESULTS AND DISCUSSION

In a first step, changes in detection efficiency were measured without the use of secondary solvent and then secondary solvent was added in 0.5 mL increments at different ratios as shown in **Fig. 1**.

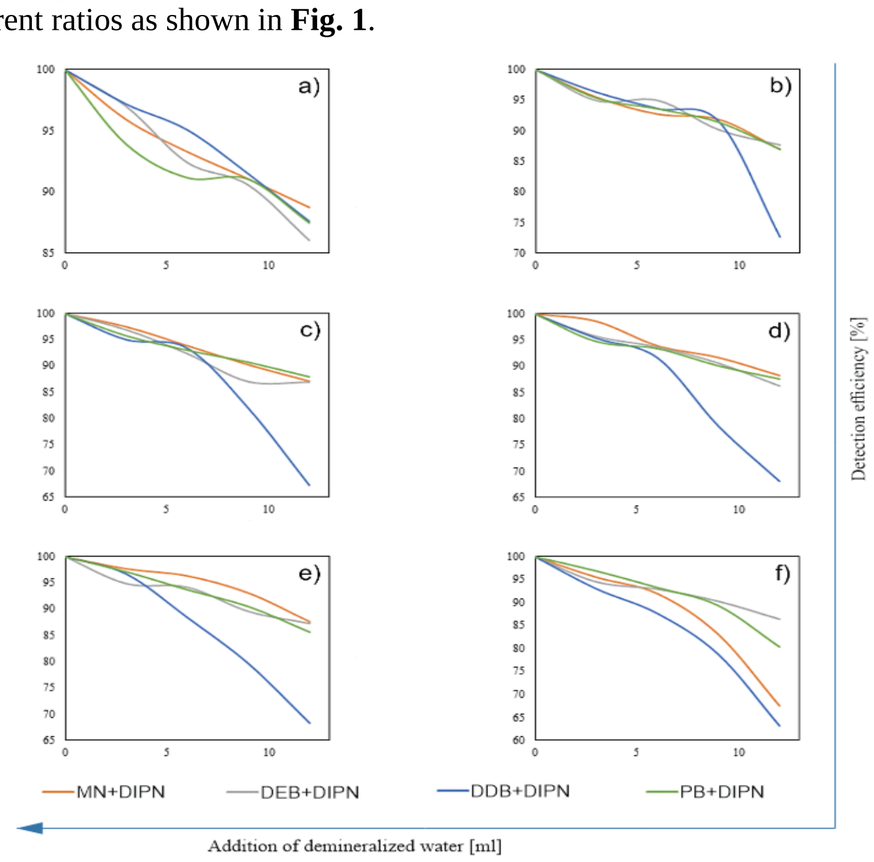

Fig. 1 Change in detection efficiency after the additions of demineralized water for solvent ratios: (a) 55 % (v/v) DIPN and 5 % (v/v) secondary solvent, (b) 50 % (v/v) DIPN and 10 % (v/v) secondary solvent, (c) 45 % (v/v) DIPN and 15 % (v/v) secondary solvent, (d) 40 % (v/v) DIPN and 20 % (v/v) secondary solvent, (e) 35 % (v/v) DIPN and 25 % (v/v) secondary solvent and (f) 30 % (v/v) DIPN and 30 % (v/v) secondary solvent.

For a more illustrative comparison, **Fig. 2** shows the dependence of the detection efficiency on the amount of secondary solvent after a total addition of 12 ml of demineralized water. Highlighted by the dashed line for comparison is the detection efficiency of DIPN without secondary solvent after the addition of 12 ml of demineralized water.

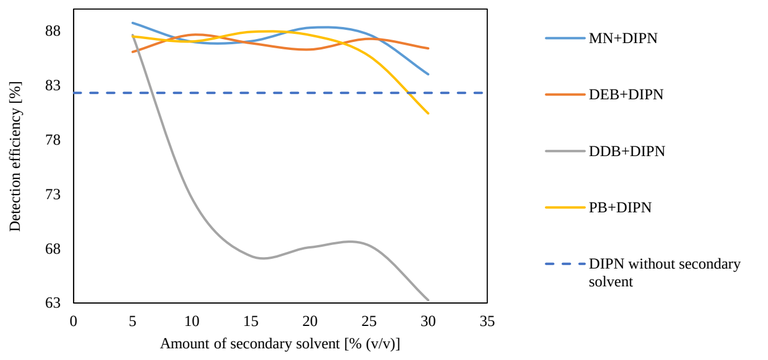

Fig. 2 The dependence of detection efficiency on the amount of secondary solvent compared to DIPN as primary solvent without secondary solvent, after a total addition of 12 ml of distilled water.

Fig. 3 and **Fig. 4** shows the 2D spectra of the investigated scintillation cocktail formulations w/wo additions of demineralized water in the combination of 40/20 % (v/v) DIPN/secondary solvent.

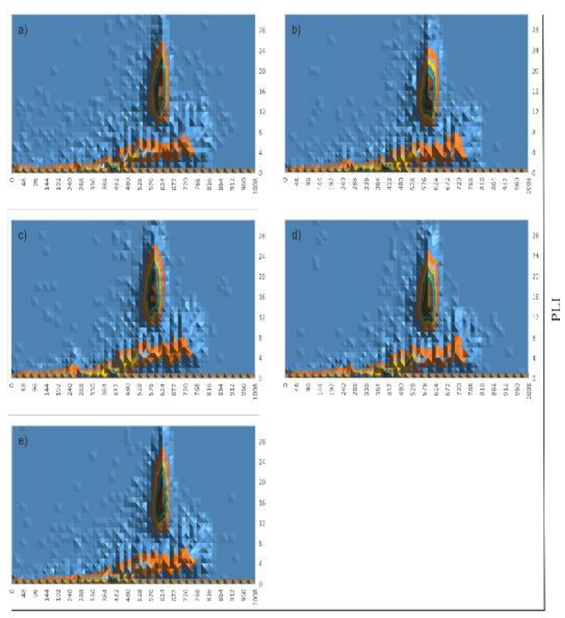

Fig. 3 2D spectra of the investigated scintillation cocktail compositions at zero addition of distilled water in the combination of 40 % DIPN + 20 % secondary solvent: a) DIPN+MN, b) DIPN+DEB, c) DIPN+DDB, d) DIPN+PB, e) DIPN without secondary solvent.

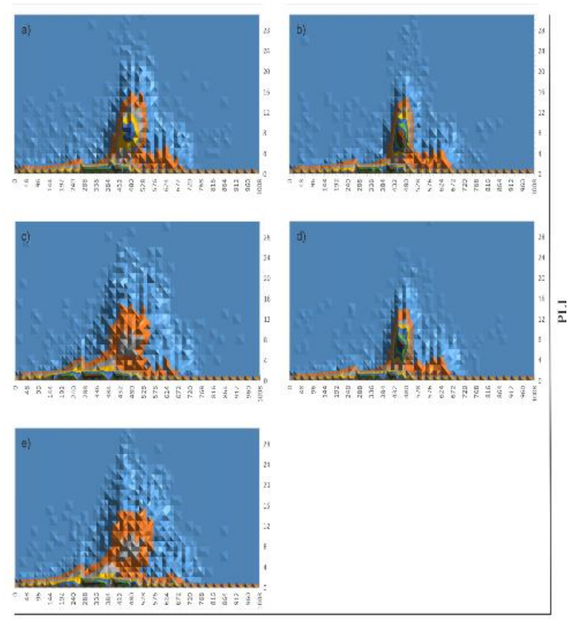

Fig. 4 2D spectra of the investigated scintillation cocktail formulations at the addition of 12 ml distilled water in the combination of 40% DIPN + 20% secondary solvent: a) DIPN+MN, b) DIPN+DEB, c) DIPN+DDB, d) DIPN+PB, e) DIPN without secondary solvent.

In the next step, a custom scintillation cocktail was created in the optimal composition of 40 % (v/v) DIPN, 20 % (v/v) MN, 30 % (v/v) Triton X-114, 6 % (v/v) BDG, 3.5 % (v/v) phosphate ester and 0.5 % (v/v) NPO (NPO-MN). It was then compared with selected commercially available scintillation cocktails, namely Aqualight, Aqualight AB and Ultima Gold XR. The results can be seen in **Table 1**.

Table 1 Properties of detection efficiency and alpha/beta discrimination of the newly designed scintillation cocktail in comparison with selected commercially available scintillation cocktails.

Scintillation cocktail	Background [DPM]	Detection efficiency			FOM
		α+β [%]	Alpha [%]	Beta [%]	
Aqualight	22±1	99.9±4	94.0±3	96.5±3	454
Aqualight AB	22±1	99.4±4	96.9±2	99.2±4	449
Ultima Gold XR	37±3	99.9±5	94.7±3	101.6±4	270
NPO-MN	21±2	101.0±5	96.8±3	100.5±3	495

According to **Table 1** NPO-MN has detection properties almost identical to the selected commercially available scintillation cocktails, and even differs slightly in FOM in which it achieved better results. The effect of the secondary solvent and detergent component on the overall sample load capacity can be seen in **Fig. 5**.

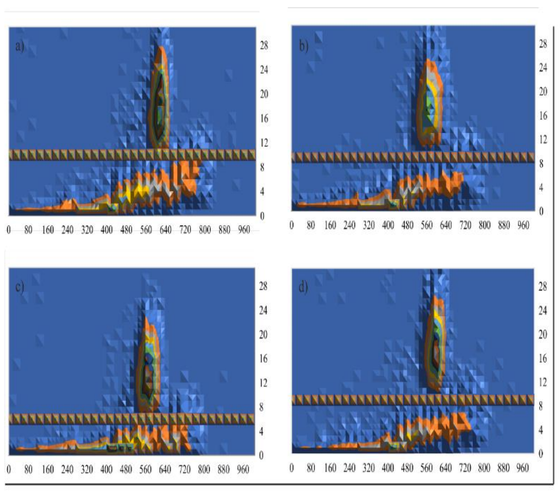

Fig. 5 2D spectra of tested scintillation cocktails: a) Aqualight, b) Aqualight AB, c) Ultima Gold XR, d) NPO-MN.

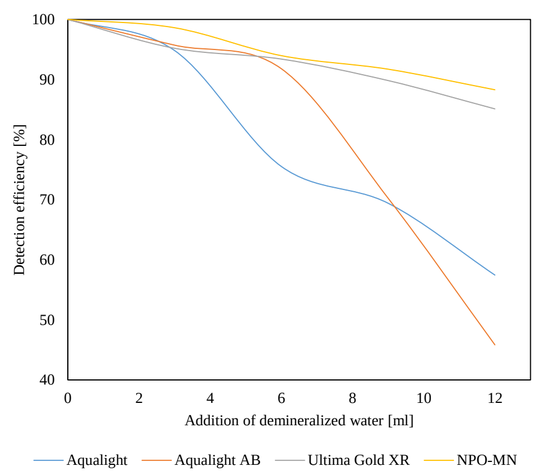

Fig. 6 Change of detection efficiency after the addition of demineralized water for selected commercial scintillation cocktails and for new scintillation cocktail

As seen in **Fig. 6**, Aqualight and Aqualight AB were significantly more quenched by demineralized water contrary to Ultima Gold XR and NPO-MN. Selected commercial scintillation cocktails and the newly designed scintillation cocktail after the addition of demineralized water are shown in **Fig. 7**.

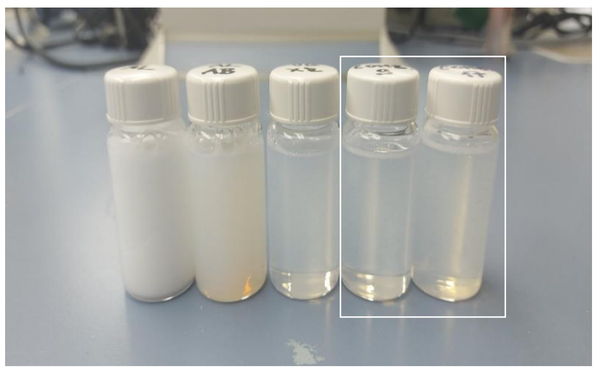

Fig. 7 Addition of 10 ml of demineralized water into a 10 ml scintillation cocktail; from left to right:
Aqualight,
Aqualight AB,
Ultima Gold XR,
NPO-MN,
NPO-MN.

CONCLUSION

1-methylnaphthalene at a ratio of 40/20 % (v/v) DIPN/MN appeared to be suitable secondary solvent for several reasons. The main advantage was the higher overall sample load capacity while maintaining high detection efficiency, especially with aqueous samples. In terms of alpha/beta discrimination properties, the new scintillation cocktail achieved excellent results. This was mainly due to the more suitable shape of the spectra, i.e. significant difference between alpha and beta pulses, which greatly facilitated PLI-based alpha/beta discrimination.