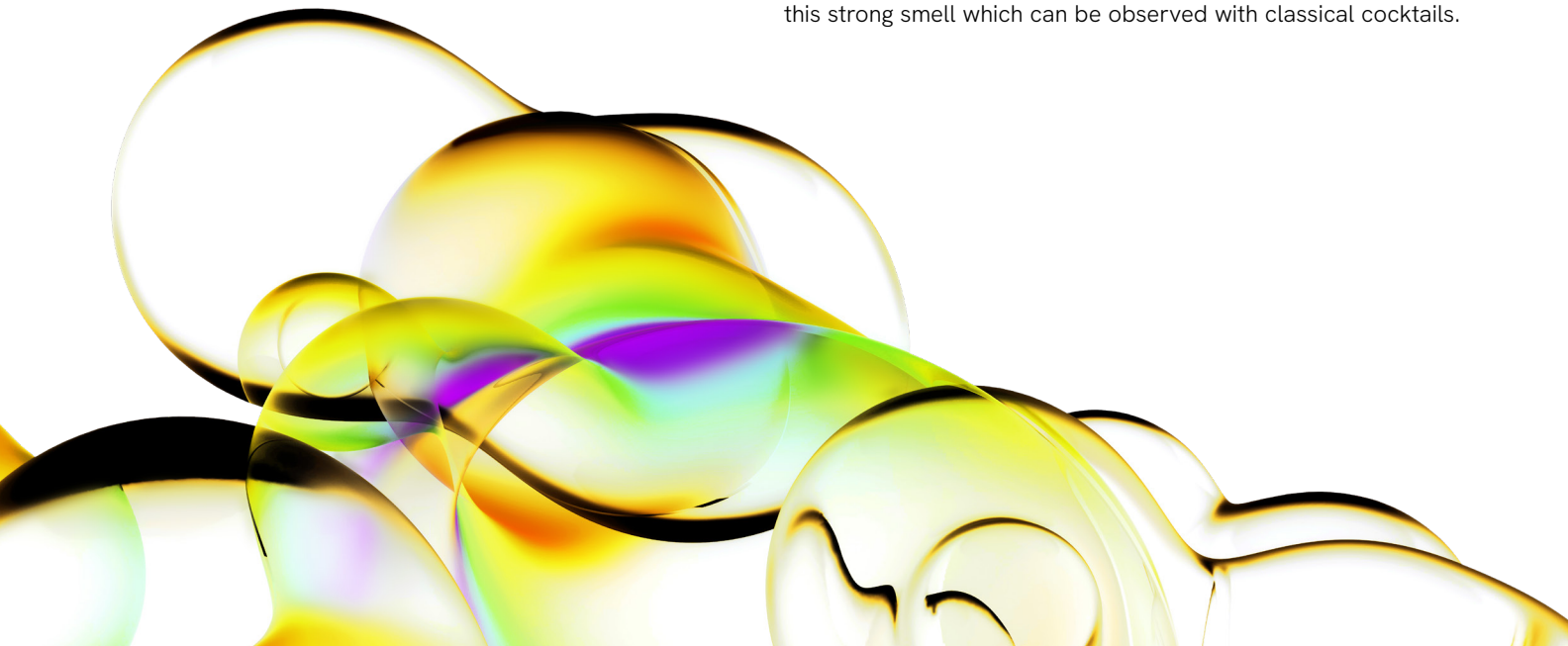
Considerations for the composition of scintillation cocktails.

Components of the cocktails

In this technical note we want to give some information about the most important cocktails from Revvity. This includes product lines of the former companies Lumac, NEN, Packard Bioscience and Wallac which are now all part of the Revvity company. In addition to this technical note you can get help from the Revvity product specialists which you can contact at any time.

It is most important to assure 4 π-geometry in liquid scintillation counting for accurate results[1]. Usually this can be assured by dissolution of the sample in an appropriate cocktail. The cocktail does not only contain a solvent but also at least one scintillator and surfactants for aqueous samples because aqueous samples are completely insoluble in the pure organic solvents and scintillators. Depending on the sample preparation and the type of sample the decision for a special cocktail can be a very important one. Only an optimized cocktail in combination with the best sample preparation guarantees accurate and reproducible results. Parameters such as counting efficiency, sample uptake capacity, flash point, uptake of buffer solutions etc. are mainly influenced by the cocktail. Today's cocktails for liquid scintillation counting are subdivided into two major groups, so called "classical" and "safer" cocktails.

Cocktails using solvents such as benzene, toluene, xylene, or pseudocumene are classical cocktails and those using linear alkyl benzene (LAB), PXE (phenylxylylethane), or DIPN (Diisopropylnaphthaline) are safer cocktails. The latter group of cocktails is less toxic and so far no carcinogenic, mutagenic or teratogenic behavior could be found. These cocktails have a much lower vapor pressure and therefore they do not show this strong smell which can be observed with classical cocktails.



The flash point of the safer cocktails is much higher, significantly higher than room temperature which makes handling of these cocktails in the lab much safer.

First of all we will talk about the components of the cocktail and discuss, why we offer a large number of different cocktails. You will see that usually it will not make sense to use a good LSC cocktail for a radio-HPLC technical but instead you should use a special radio-HPLC cocktail.

In addition to vial LSC cocktails and radio-HPLC cocktails there are also special cocktails for microplate counters. A good cocktail has to show mainly the following properties:

1. Good uptake capacity
2. Low content of natural ^{14}C
3. High transmission for photons
4. High quantum yield
5. It should be a safer cocktail
6. The cocktail should be usable for a wide range of technicals
7. Low price (good price/performance ratio)

It is extremely difficult, if not impossible, to develop a cocktail which guarantees all the seven points just mentioned. Also many users have different technicals and therefore have different priorities. For a user in the field of environmental monitoring it can be very important to have a cocktail with very high uptake capacity, another user on the other hand might have a very low price for the cocktail as the highest priority. Over the decades this lead to a huge range of cocktails and it is difficult to give an overview for all these cocktails, even for a specialist. The product range includes some universal cocktails as well as cocktails for very special technicals. The universal cocktails can be used for a wide range of technicals, however, in some cases best performance can be obtained with cocktails for special technicals. On the other hand these special cocktails are usually limited in the range of technicals. Most of the important universal as well as special cocktails will be explained in this technical note.

A cocktail contains in general four different components (4 s rule):

1. Solvent
2. Scintillator
3. Surfactant
4. Sample

Surfactants are not components of all cocktails. They are only part of those cocktails which are designed for the uptake of aqueous solutions. On the following pages we will discuss all the components of cocktails.

Solvent

There are mainly two reasons why we use solvents in cocktails. First of all we have to dissolve the sample and the scintillator and secondly the solvent is important for the energy transfer from the radioisotope to the scintillator. Solvents with large conjugated π-electron systems are very well suited for the energy transfer from a radionuclide to the solvent. These π-electrons are easily excited. A typical group of compounds with π-electron systems is the group of aromatic hydrocarbon compounds. Besides the ability to transfer the energy the solvents in a scintillation cocktail must have the following capabilities:

1. It has to dissolve the radioactive sample and the scintillator fast and completely.
2. It should contain a small amount of natural ^{14}C activity.
3. It should have a high transmission for photons emitted from the scintillator.

A list of the most used solvents is shown in Figure 1. Among the properties of the solvents the relative pulse height and the flash point are of special interest. Both properties are listed in the following figure.

The reference value for the relative pulse height is per definition 100 for toluene. The flashpoint is the lowest temperature which allows self ignition of the gases of a flammable liquid in air.

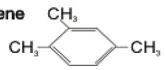
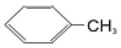
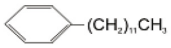
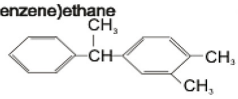
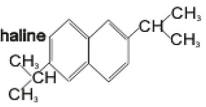
Solvent	Structure	Relative Pulse Height	Flash-Point (°C)
1,2,4-Trimethylbenzene (Pseudocumene)		112	50
1,4-Dimethylbenzene (P-Xylene)		110	30
Methylbenzene (Toluene)		100	5
Benzene		85	-11
1,4-Dioxane		65	12
Dodecylbenzene		91	150
1-Phenyl-1-(3,4-dimethylbenzene)ethane (PXE)		114	150
2,6-Di-isopropylnaphthaline (DIPN)		114	150

Figure 1: Solvents in liquid scintillation cocktails.

The relative pulse height (which is 100 per definition for toluene) is a very important value. If this value is below 100 the energy transfer and the number of resulting photons is reduced to a level which cannot be accepted for today's modern LSC cocktails. Therefore safer cocktails are based on DIPN or PXE and classical cocktails are mainly based on Pseudocumene.

Still we have some safer cocktails on the basis of linear alkylated benzenes (LAB´s) although they show relative low pulse height values. The flash point of the cocktail is not important for the measurement but for the safety in your laboratory. Solvents with higher flash point can not be easily ignited and are usually less toxic.

Materials with low flash point in most cases also show high vapor pressure which results primarily for classical cocktails in a higher concentration of these materials in air. You also smell the classical cocktails and you should use a hood to avoid health problems. Table 1 shows possible concentrations of solvents in air.

Table 1: Possible concentrations of solvents in air.

Solvent	Vapor pressure at 25 °C (mM Hg)	Equilibrium constants at 25 °C (ppm)
1,4-Dioxane	40	52600
Toluene	28	36200
m-Xylene	8	10900
Pseudocumene	2	2760
DIPN	1	< 2

One of the first solvents used for liquid scintillation counting was benzene. It was mainly replaced by other solvents because of the toxic and carcinogenic properties and the very low flash point.

Dioxane was also one of the very early solvents in LSC cocktails. It was used in Bray´s cocktail together with naphthalene. However, this cocktail could not be used for aqueous solutions containing proteins.

Also many samples resulted in the crystallization of naphthalene in the measurement vials. Dioxane which is a cyclic ether also tends to show self oxidation under the influence of air. The produced peroxides are strong quencher and also cause problems with strong chemiluminescence. These problems together with the low flash point and the high toxicity resulted in the replacement of Dioxane.

In the following time a series of alkyl substituted benzenes were used as solvents. The simplest alkyl substituted compound is toluene (methylbenzene). Solvents on the basis of toluene together with TRITON X-100® became the first emulsifying cocktails which could be used for the measurement of aqueous samples. Toluene is commercially available for a low price and with high purity but the flash point of this material is still below room temperature and lately research seems to indicate that toluene shows carcinogenic effects.

If you add another methyl group to toluene you will get xylene (dimethylbenzene). If you have two methyl groups within the benzene ring you can have three different isomers. You can have ortho- (1,2-dimethylbenzene), meta- (1,3-dimethylbenzene) or para-Xylene (1,4-dimethylbenzene). You can use pure xylenes or xylenes in known ratios. Only pure para-xylene can not be used because it is a solid at 12-13 °C. The quantum efficiency as well as the relative pulse height is good for xylene. Xylene is classified as a highly flammable liquid (but this is true for almost all organic solvents) but the flash point is already above room temperature.

Also the classical Insta-Fluor cocktail used xylene in the past but in this cocktail the solvent has been replaced by pseudocumene. You get pseudocumene of you add a third methyl group to the benzene ring. Pseudocumene (1,2,4-trimethylbenzene) has some properties which make this solvent an ideal candidate for a cocktail solvent. First of all pseudocumene can be used for a very efficient energy transfer (see Figure 1). Also pseudocumene is only classified as a normal flammable liquid therefore the regulations for transportation of this solvent are less strict.

Another important point is that the diffusion into plastic vials is reduced significantly compared to benzene or xylene. Therefore pseudocumene cocktails can be used with plastic vials for many technicals. Among the classical cocktails based on pseudocumene you will find Revvity cocktails such as Pico-Fluor, Filter-Count, Hionic-Fluor, InstaGel Plus, and Flo-Scint II.

All cocktails mentioned so far belong to the family of the so called "classical cocktails". Despite some excellent properties for LSC measurements customers more and more wanted to use "safer cocktails" in the laboratory.

Most customers did not like classical cocktails because they had very low flash points but also because of the strong smell mainly caused by the high vapor pressure. This resulted in the development of "safer cocktails" which meanwhile can be used for LS-counters as well as for the Radio-HPLC detector. Lately the safer cocktails have replaced some of the traditional classical cocktails.

The safer cocktails are based on linear alkyl substituted benzenes (LAB), PXE or DIPN. Among these cocktails you will find the Ultima Gold series of cocktails and the Radio-HPLC Ultima-Flo AP. All these cocktails show very high flash points between 120 and 150 °C and at the same time they are degradable in the environment. Figure 2 shows the speed of degradation of today's solvents in safer cocktails[5].

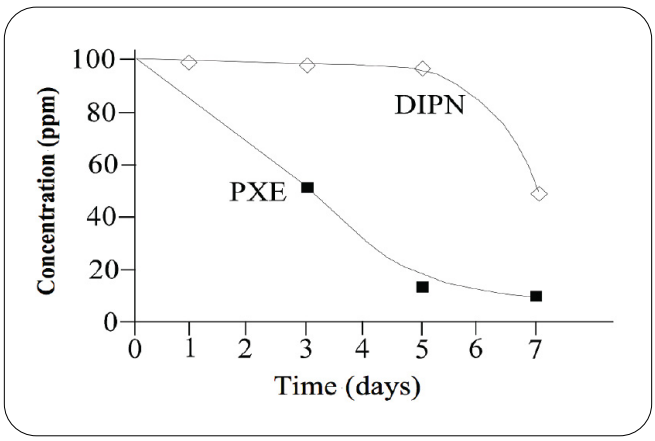


Figure 2: Biological degradation of solvents.

Ultima-Flo AP which is based on benzyltoluene (BT) and diphenylethane (DPE) can be classified as biodegradable using the Zahn/Wallens EMPA Test (equivalent to OECD 302B). With the safer cocktails you can get high counting efficiencies and high sample uptake capacities.

Primary scintillators

Scintillators can be excited by taking over the energy of excited solvent molecules. For a short time the scintillators will stay in an excited energy level and on their way back to the ground state excess of energy will be emitted as photons. A detector (Photomultiplier Tube, PMT) can measure the amount of light. The process of energy transfer to the scintillator has to be very efficient to allow very sensitive detection of radio nuclides. The process should also be very quantitative and the energy of the β-particle should be proportional to the energy of the resulting photons which are emitted from the scintillator. Figure 3 shows some of the used primary scintillators.

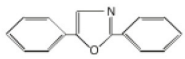
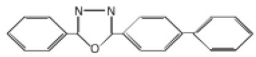
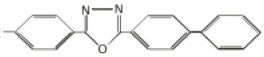
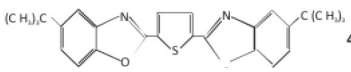
Name	Structure	λ (nm)	t (nsec)	Φ
PPO		375	1.4	0.83
PBD		375	1.0	0.69
Butyl-PBD		385	1.0	0.69
BBOT		446	1.6	0.61

Figure 3: Properties of primary scintillators.
λ = fluorescence maximum, t = decay time,
Φ = quantum yield, PPO = 2,5-diphenyloxazole,
PBD = 2-phenyl-5-biphenyl-1,3,4,-oxadiazole,
butyl-PBD = 2-(4-tert-butylphenyl)-5(4-biphenylyl)-1,3,4-oxadiazole,
BBOT = 2,5-bis-2-(tert-butylbenzoxazolyl)-thiophene

Primary scintillators are added to cocktails in concentrations between 5 and 12 g/L. If the scintillator concentration is too high this can negatively influence the cocktail because it can result in quench of photons. One of the older primary scintillators is naphthalene which is only used in special cases nowadays. This scintillator has not been used for Radio-HPLC cocktails but was added to classical cocktails. In comparison to cocktails based on DIPN the classical cocktails show a very short pulse length. Naphthalene was added to the classical cocktails to increase the pulse length and therefore improve the α/β-discrimination.

This discrimination is much easier if the pulses are stretched. DIPN cocktails do not need this addition of naphthalene anymore because the solvent itself is a derivative of naphthalene and shows the corresponding pulse length increase.

Secondary scintillators

Some of the primary scintillators show an emission wavelength clearly below 400 nM. However, the PMT´s used in modern liquid scintillation analyzers are especially sensitive at a wavelength around 420 nM. Secondary scintillators are also electron rich compounds which can be excited very easily. The main advantage of secondary scintillators is the wavelength of the emitted light, which is much closer to the sensitive area of the PMT. Secondary scintillators are mainly used to shift the wavelength of the light to the sensitive range of the PMT.

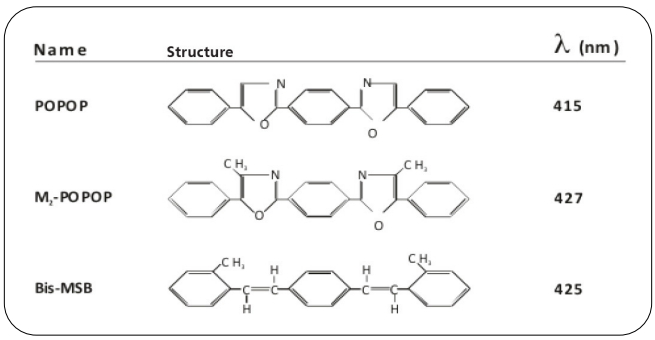


Figure 4: Secondary scintillators.

The name POPOP, 1,4-(di-2-(5-phenyloxazolyl))-benzol, belongs to the alternating phenyl- and oxazole-units. In some cases POPOP is also used in the twofold methyl substituted derivative. The name bis-MSB is an abbreviation for p-bis-(ortho-methylstyryl)-benzene.

Emulsifier (Surfactants)

Many samples which will be measured in classical LSC´s, microplate counters or radio-HPLC systems with reversed phase columns will be disolved in aqueous solution. Therefore an absolute necessity for many cocktails is a very high sample uptake capacity for aqueous solutions. In addition, sometimes these solutions can also contain high amounts of buffers. The following figure shows some typical emulsifiers which are used in cocktails for liquid scintillation counting. Typically the structure of emulsifiers contains a polar end to dissolve the aqueous part and a nonpolar end to dissolve the organic solvent. The real art of cocktail manufacturing is finding the optimum composition of all the parts which make up a complete cocktail. The cocktail should have enough emulsifier to improve the sample uptake capacity but not too much emulsifier to prevent a reduction in counting efficiency. Figure 5 shows some of the emulsifiers which can be found in cocktails.

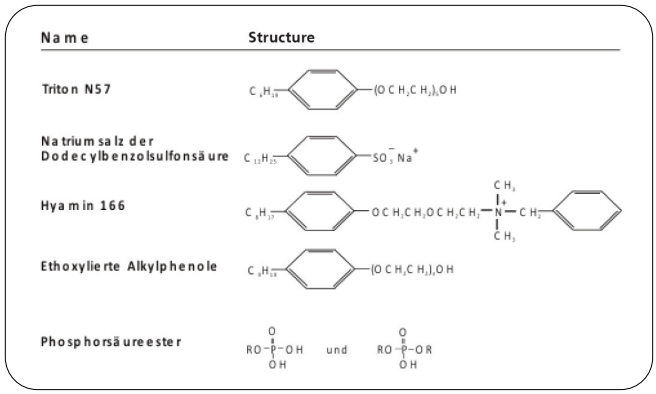


Figure 5: Typical surfactants in scintillation cocktails.

In most cases Radio-HPLC cocktails for aqueous eluents show lower counting efficiencies compared with cocktails for classical counters. Radio-HPLC cocktails contain a very high amount of emulsifiers. The reason for this is that these cocktails not only have to take up a lot of aqueous sample but it is also necessary that a stable homogeneous phase is created instantly without mixing.

Viscosity of the cocktails

A very important point for the decision of the optimum cocktail is the viscosity of the cocktail. In general the viscosity of radio HPLC cocktails from Revvity is lower than the viscosity of classical LSC cocktails. The lower viscosity helps to get faster a stable homogeneous solution. The increase of emulsifier concentration on the other hand results in lower viscosities. Classical LSC cocktails which are sometimes cheaper can usually not be used for radio HPLC technicals.

Today, low viscosity cocktails are absolutely necessary for radio HPLC detectors in narrow and microbore technicals. If cocktails show too high viscosity these cocktails will result in high back pressure and can damage the expensive flow cells.

The viscosity η will be described in units of Nsm^{-2} or $kg\ m^{-1}\ s^{-1}$ or in P (Poise) = $g\ cm^{-1}s^{-1}$.

Often the fluidity is used η^{-1} which is the inverse of the viscosity. Sometimes the kinematic viscosity is used to describe the viscosity of a sample. This value can be calculated using the following equation:

Kinematic viscosity = $\frac{\eta}{\rho}$ [$cm^2\ s^{-1}$ = Stokes]

From the following table you can find the viscosities of some cocktails and typical HPLC eluents. Instead of Stokes (St) often centi Stokes (cSt) are used to get numbers larger than 1.

From Table 2 you see that Ultima-Flo AP shows lower viscosity than Ultima Gold which is used for measurements in classical liquid scintillation analyzers. Despite this optimization of cocktails the viscosity is still much higher than typical HPLC solvents such as water, methanol or acetonitrile. For this reason you should avoid flushing your radio-HPLC detector at high flow rates because it will probably result in overpressure.

Table 2: Kinematic viscosity of cocktail- and alcohol-water mixtures[6].

		Ratio of cockail: water			
		No sample	3:1	2:1	1:1
Kinematic viscosity (cSt)	Ultima-Flo AP	14	20	22	19
	Ultima Gold	26	48	**	**
	Water	1	-	-	-
	Methanol	0.7	1.8	1.9	1.9
	Ethanol	1.5	2.5	2.9	3.1

Table 3. Table of cocktails.

	Cocktail	Solvent	Flash point (°C)	Eff. without sample	Eff. with 10% solubilizer	Eff. with 10% water	Uptake capacity for water (mL)*
Cocktails for aqueous and organic samples	Ultima Gold	DIPN	~ 150	56	49	52	2,5
	Ultima Gold XR	DIPN	~ 150	50	–	46	10
	Ultima Gold LLT	DIPN	~ 140	52	-	46	12
	Ultima Gold uLLT	DIPN	~ 140	52	-	46	12
	Ultima Gold MV	DIPN	~ 110	57	-	55	1
	Ultima Gold AB	DIPN	~ 140	52	-	46	10
	Ultima-Flo AP	BT/DPE	~ 120	43	-	-	10
	Emulsifier-Safe	LAB	~ 150	43	-	39	1,5
	OptiPhase HiSafe III	DIPN	144	47	-	43	11
	Insta-Gel Plus	pseudocumene	48-50	56	-	48	1,3 & 3-10
	Filter-Count	pseudocumene	48-50	57	-	53	1
	Hionic-Fluor	pseudocumene	48-50	51	48	45	1
	Monophase S	pseudocumene	48-50	-	-	-	-
	Permafluor E+	pseudocumene	48-50	-	-	-	-
	Flo Scint II	pseudocumene	46	55	-	-	-
Cocktails for pure organic samples	Ultima Gold F	DIPN	~ 150	65	-	Only for pure organic samples	
	OptiScint HiSafe	DIPN	~ 150	61	-		
	Insta-Fluor Plus	pseudocumene	48-50	65	57		
	Econofluor-2	pseudocumene	48-50	-	-		
	High Eff. Min. Szint.	pseudocumene	79	-	-		

* This column shows the uptake capacity for aqueous samples in 10 mL of cocktail.
Orange indicates 'Safer' line of LSC cocktails.
Blue indicates 'Classical' line of LSC cocktails.

Cocktails for classical scintillation counters

Cocktails for classical scintillation counters for the measurement in scintillation vials with volumes between 6 and 20 mL are still the main technical for scintillation cocktails. The difference here is the relatively large measurement volume and the possibility to shake a vial very efficient in your hand or a shaker. As we have already mentioned above cocktails contain solvents of low vapor pressure. This on the other hand results in a higher viscosity of LSC cocktails. The amount of emulsifiers is restricted to avoid the reduction of the counting efficiency. As we will see on the following pages, this is the most important difference between radio HPLC cocktails and LSC cocktails. On the following pages we will briefly describe many of the available cocktails from Revvity.

Safer cocktails on basis of DIPN, PXE or LAB

The following cocktails are based on one or more of the above mentioned solvents. All these cocktails are good or very good biodegradable. None of these solvents show diffusion into polyethylene vials. This means that measurements in polyethylene vials can be done even for longer measurement times.

Ultima Gold

This cocktail is a safer cocktail based on diisopropylnaphthalene (DIPN) originally developed by Packard and shows good counting efficiency for ^{3}H in organic and aqueous samples of up to 56%. This is the cocktail of choice if you want to avoid using many different cocktails for samples of different nature. This cocktail is also very quench resistant. The flash point is 150 °C

Emulsifier Safe

Emulsifier Safe is a cost reducing alternative for Ultima Gold or OptiPhase HiSafe 2. The cocktail is based on LAB as the solvent. It forms homogeneous solutions with organic and aqueous samples with a maximum uptake capacity of 10-15%. This cocktail has a high flashpoint of 150 °C.

Ultima Gold XR

This cocktail has especially been developed for extremely high uptake capacities for aqueous samples but can also be used for organic samples. The cocktail has been developed by Packard. In some cases a ratio between cocktail and sample of 1:1 is possible which allows the user to place much more sample into a measurement vial.

Sometimes it is possible to reduce the amount of cocktail and to switch from a 20 mL vial to a 6 or 8 mL vial. This can significantly reduce the waste volume and the costs for waste disposal. This way the user can save a lot of money although the cocktail is slightly more expensive than Ultima Gold. The cocktail also uses DIPN as the solvent and shows high quench resistance and a flash point of 150 °C. The counting efficiency is slightly reduced to 50% for ^{3}H. This is a result of the higher amount of emulsifiers. Because of the much higher uptake capacity of this cocktail you will overall find a clearly better lower limit of detection for this cocktail.

OptiPhase HiSafe 3

This cocktail, originally developed by Wallac Oy, which is based on DIPN, accepts samples with high ionic strength and can take up large volumes of aqueous sample. The cocktail is comparable with Ultima Gold XR. The flash point is 148 °C.

Ultima Gold LLT

If you are interested in low level technicals this might be the cocktail of choice for you. It has originally been developed by Packard. You will get low background rates and high sample capacities comparable with Ultima Gold XR.

Uptake capacity is up to 54%, this means the sample can contain a little bit more water than cocktail.

Besides this, the cocktail also shows very high uptake capacities for heavy metals and strong mineral acids such as 2M HNO_3 (up to 18%) HCl or H_3PO_4. The α-/β-discrimination is also very good. Therefore Ultima Gold LLT can be used as an alternative for Ultima Gold AB. The cocktail shows high quench resistance and a flash point of 140 °C.

Ultima Gold uLLT

In terms of performance practically identical with Ultima Gold LLT but this cocktail gives lowest background values. No raw materials containing any biogenic materials will be used during the production process thus reducing the amount of ^{14}C and ^{40}K in the final cocktail.

Ultima Gold MV

Ultima Gold MV is the cocktail with the lowest viscosity within the Ultima Gold series of cocktails and has originally been developed by Packard. This cocktail shows very good counting efficiency for ^{3}H of 57%. It is used if you need very easy dissolution of your sample in cases of very small volumes or for the measurement of filters.

The ability to moisten filters is reduced in some of the more viscous cocktails and here Ultima Gold MV might work. As all cocktails within the Ultima Gold series this cocktail also shows high quench resistance. The flash point of this cocktail is at 110 °C.

Ultima Gold F

This cocktail has the best counting efficiency for ^{3}H of up to 63% for unquenched samples and has also been developed by Packard. The high counting efficiency is mainly due to the fact that this cocktail does not contain any emulsifiers. Therefore this cocktail can only be used for pure non-polar organic material. This cocktail can not be used for aqueous samples. But also highly polar organic samples such as methanol or acetylacetate can not be used. Completely dry filters or Filtermats can be measured. This cocktail shows high quench resistance and has a flash point of 150 °C.

Ultima Gold AB

We already mentioned this cocktail when we discussed Ultima Gold LLT. This cocktail is the only one in the market especially developed by Packard for α-/β-discrimination. The counting efficiency of ^{3}H in unquenched samples can be as high as 52%. This cocktail also accepts high amounts of mineral acids and has a high sample uptake capacity. It shows high quench resistance and has a flasch point of 140 °C.

Classical cocktails based on pseudocumene

Although the use of classical cocktails decreases since more and more safer equivalents are available still some classical cocktails are useful for special technicals. There are even some classical cocktails for which safer alternatives are not available.

Insta-Gel Plus

This is one of the classical cocktails which are still in widespread use. This cocktail came originally from Packard in Groningen, Netherlands and is a cocktail which forms gels. In the gel phase this cocktail has a very high uptake capacity of up to 50% which is comparable with the uptake capacity of the safer cocktails for aqueous samples such as Ultima Gold XR and Ultima Gold LLT. The cocktail can be used in homogeneous phase with small sample volumes (0-2 mL water) or in the gel phase with larger volumes (4-10 mL water) per 10 mL of cocktail. After shaking of the mentioned volume of water and cocktail the gel appears in a few seconds. Between homogeneous and gel phase there is a two phase heterogeneous system where measurements are not possible. In the gel phase the cocktail can be used to measure 14 °C scratched from TLC´s or other suspended solids. The cocktail shows only little diffusion into polyethylene vials and has a flash point at 50 °C.

Insta-Fluor Plus

Packard in the Netherlands originally developed this cocktail. It is only suited for pure organic samples because it does not contain any emulsifiers. This cocktail can not be used with aqueous solutions. Only recently xylene has been replaced by pseudocumene in this cocktail. The ^{3}H counting efficiency can be very high, up to 65% in unquenched samples. The cocktail is stable against chemiluminescence and can be used for two phase extractions. Therefore we recommend this cocktail for the measurement of radon in so called Pico-Rad detectors. In these detectors radon bound to active carbon can be extracted with Insta-Fluor Plus. The viscosity of this cocktail is relatively low. This allows using this cocktail in radio HPLC technicals with the exception of narrow or microbore HPLC. However, eluents have to be purely organic which means that reversed phase chromatography is not possible with this cocktail. The cocktail has a flash point of approximately 50 °C and shows only low diffusion into polyethylene vials.

High efficiency mineral oil scintillator

This cocktail does not contain any emulsifiers and is therefore only suitable for organic samples. It is an excellent cocktail for the measurement of radon in water (extracting all the radon into the cocktail) and soil samples. Counting efficiencies for radon are comparable with solid scintillators. The cocktail mainly consists of mineral oil and up tp 20% of pseudocumene. The flash point is 79 °C.

FilterCount

This is a very special cocktail developed by Packard and there is no safer alternative available. The cocktail is based on pseudocumene and has been especially developed to dissolve cellulosenitrate membrane filters. It can also be used to dissolve mixed cellulose esters and PVC filters but the latter will need more time. Complete dissolution of filters guarantees a perfect and homogeneous 4π-geometry. This means that quench curves can be used and that physical quench can be avoided. Physical quench can be a problem for ^{3}H labeled samples and can result in a significant reduction in the ^{3}H counting efficiency (potential danger to oversee ^{3}H contaminations in wipe tests). FilterCount can be used for organic and aqueous samples and ^{3}H counting efficiencies in unquenched samples of up to 57% are possible. The cocktail shows low amount of diffusion into polyethylene vials.

Hionic Fluor

This cocktail came originally from Packard and is based on pseudocumene. It has especially been developed to accept samples with high ionic strength. This cocktail accepts high amounts of sucrose and cesiumchloride. It can also be used for tissue solubilizer such as Soluene-350 and Solvable. Hionic-Fluor shows high quench resistance especially in presence of trichloroaceticacid. Chemiluminescence decays much faster with this cocktail than with any other cocktail. It shows low diffusion into polyethylene vials and has a flasch point of 50 °C.

Cocktails for oxidizers

Monophase S

This cocktail has been developed by Packard for use in the sample oxidizer models 306, 307 and 387. The cocktail can be used with pure aqueous samples and has an uptake capacity of 23%. It is not foaming und does not produce gels. The cocktail is based on pseudocumene and only shows little diffusion into polyethylene vials. The flash point is at 50 °C.

Permafluor E+

As already mentioned for Monophase S this cocktail has also been developed for the use with the Revvity oxidizers. It is for the use with ^{14}C samples ($^{14}CO_2$) which are bound to Carbosorb. The cocktail is based on pseudocumene and only shows little diffusion into polyethylene vials. The flash point of this cocktail is at 50 °C.

Cocktails for Radio-HPLC

Caution: Because of the high viscosity of classical LSC cocktails and the problems to get homogeneous mixtures with the low viscosity HPLC eluents classical LSC cocktails are usually not suitable for radio-HPLC technicals. For radio-HPLC please only use one of the following cocktails.

Safer Radio-HPLC cocktails

In the following section you will see that the radio-HPLC cocktails have significantly lower ^{3}H counting efficiencies than normal LSC cocktails. As already mentioned, radio-HPLC cocktails include a much higher amount of emulsifiers. The emulsifier component can be as large as 50% of the total cocktail volume. This reduces the relative amount of solvent and scintillator thus reducing the counting efficiency.

Ultima-Flo AP

The ending "AP" for this cocktail has been chosen because Packard developed this cocktail for ammoniumphosphate buffers. However, this cocktail also shows excellent performance with a wide range of different eluents and therefore nowadays "AP" is used for "all purpose". 3H counting efficiencies of up to 43% are possible. The cocktail is based on benzyltoluene and diphenylethane and has a flash point at 120 °C.

Classical Radio-HPLC cocktails

Flo-Scint II

This cocktail has been developed by Packard. This cocktail shows strong resistance against chemiluminescence and accepts diluted buffers. It consists of pseudocumene and petroleum. The flash point is at 46 °C. ^{3}H counting efficiencies can be as high as 55%, however, this requires a 4-5 fold excess of cocktail.

Special cocktails for the MicroBeta^2

Caution: MicroScint cocktails contain a special formulation resulting in very long pulse durations. This is of high importance for the time resolved background reduction. Therefore you should only use MicroScint cocktails in the MicroBeta^2.

All MicroScint cocktails have been developed by Packard. They all contain PPO as the scintillator as well as DIPN and 9, 10-dimethylanthracene as the solvent. Further components are included for special performance. All MicroScint cocktails are safer, biodegradable cocktails.

MicroScint O

This cocktail is based on DIPN and 9,10-dimethylanthracene to increase the pulse length. The cocktail does not contain any emulsifiers and can not be used with aqueous samples. It is the ideal cocktail for organic samples or dried filters. With MicroScint O you can get ^{3}H counting efficiencies of up to 58%. The flash point of MicroScint O is at 152 °C.

MicroScint 20

This cocktail uses the same solvent as MicroScint O but also emulsifiers such as ethoxylated alkylphenols. The uptake capacity for aqueous samples is 20%. The maximum ^{3}H counting efficiency in a white 24 well OptiPlate is 52%. It is the best cocktail for wet filters. Mixing of the cocktail with sample is simple on an orbital shaker. The flash point of MicroScint 20 is at 152 °C.

MicroScint PS

This cocktail is comparable with MicroScint 20 but it is especially compatible with polystyrene plates. Many other cocktails can dissolve polystyrene during longer measurement times. Part of the DIPN has been replaced by mineral oil in this cocktail. With MicroScint PS you can get ^{3}H counting efficiencies in white 24 well Optiplates of up to 48%. MicroScint PS has a flash point of 162 °C.

References

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