

LSC CONSUMABLES



LSC cocktails



Cocktails for measuring Radon



Oxidizer/Pyrolyzer supplies



Solubilizers



Vials

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PRINCIPLES OF LSC COCKTAILS

Liquid Scintillation Counting (LSC) or Liquid Scintillation Spectrometry is one of the most important and versatile nuclear measurement techniques. This is mostly due to some of its unique features:

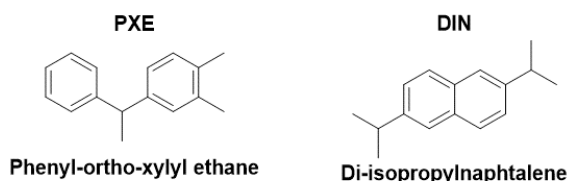
- Quantification of beta emitters, including soft beta emitters such as H-3, Pu-241 and Pb-210, as well as alpha emitters
- Possibility of counting a wide range of sample types such as liquid samples (organic and aqueous), solid samples (using a jelling cocktail) and gaseous samples (e.g. Rn) by choosing the most appropriate cocktail
- Availability of spectral information of the sample

In order to allow quantifying radioactive emissions by LSC samples there is a requirement for the radioactive material to be in close contact with the scintillating medium, which in case of LSC is the so-called LSC Cocktail.

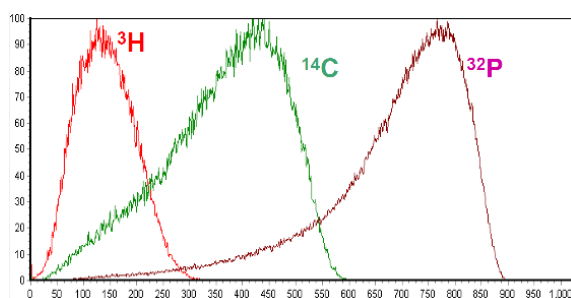
LSC Cocktails consist of at least three components:

1. Solvents:

By far largest part of the cocktail is an aromatic, organic solvent such as di-isopropylnaphtalene (DIN), phenyl-o-xylylethane (PXE), pseudocumene or toluene.



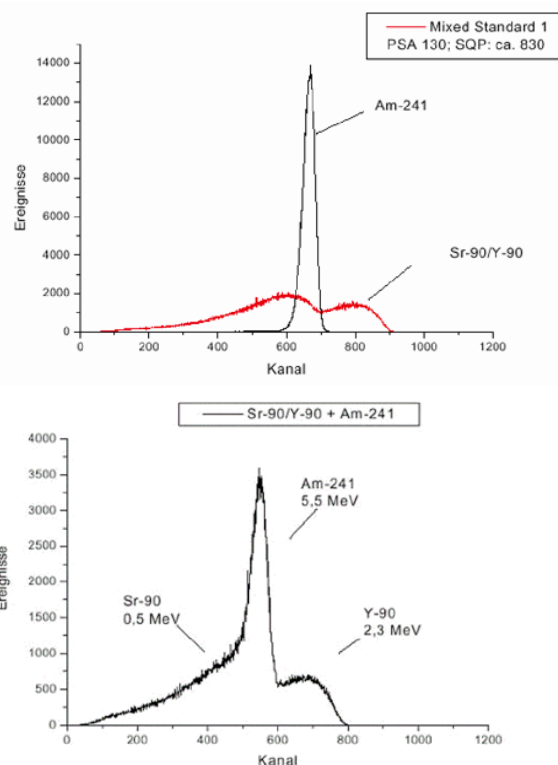
The solvent is collecting energy from the emitted alpha or beta particle through their interaction with the π cloud of its aromatic rings. This energy is then transferred to the Scintillator(s). The higher the energy of an emitted particle the larger the number of excited solvent molecules this allows for obtaining spectral information. Beta particles are not emitted at a discrete energy so they do not show a distinct peak but rather a signal with a continuous energy distribution between their maximum emission energy ($E_{\beta, \max}$) and zero. This makes the accurate simultaneous determination of several beta emitters very challenging, especially for beta emitters with similar energies. Very often it is necessary to perform a chemical separation in order to remove other radioelements before the measurement.



Spectra of various beta emitters, logarithmic scale. Taken from Hou¹

Alpha particles emit at a specific energy but with 10% of their E_{\max} . The reason is that the number of photons released for alpha is less than beta as more energy is used in the disintegration of the ejected species. Alpha decay releases approximately 1 photon per 1 keV of energy whereas beta decay releases approximately 10 photons per keV of energy.

Because of this, alpha and beta emitters may appear in similar counting channels within the spectrum (despite their often very different energies) making their quantification challenging. Ideally a chemical separation, e.g. using extraction chromatography, should be employed to separate both. In case this is not possible (e.g. two or more isotopes of the same element, one alpha and one beta emitter are present) so called alpha/beta discrimination counting needs to be employed.



Spectra of mixture of Sr-90 and Am-241, with and without alpha/beta discrimination counting. Taken from Happel²

2. Scintillator(s)

Sometimes also referred to as fluors(s).

The task of the scintillator(s) is the conversion of the excitation energy of the solvents into light emissions of suitable wavelength for detection by a photomultiplier. Scintillators are generally characterized by large π systems or linked benzene rings. In order to improve detection efficiency very frequently two different scintillators are used:

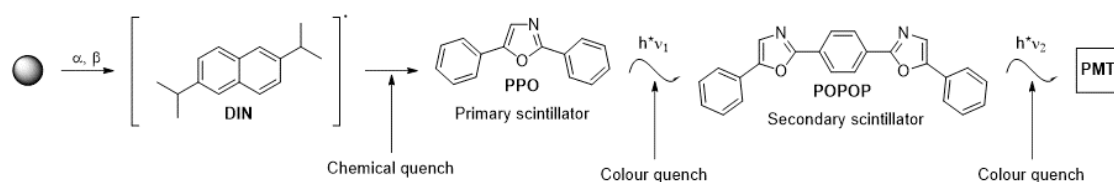
- Primary Scintillator (e.g. Butyl PBD, PPO or p-Terphenyl) having an emission wave-length of < 400 nm and
- Secondary Scintillator or Wavelength shifter (e.g. Bis-MSB or POPOP) with an emission wave-length of > 400 nm.

3. Surfactants

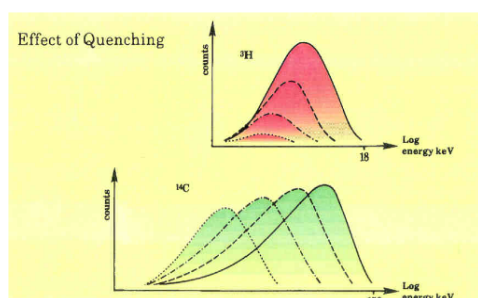
For aqueous samples a third component - a surfactant - is needed to allow close contact of the aqueous sample and the organic compounds of the cocktail.

Having one single transparent phase/homogenous mixture of sample and LSC cocktail (only exception mineral oil cocktails for Rn in water) is one of the most important prerequisites for accurate and reproducible quantification of radionuclides by LSC. Accordingly, it is crucial to choose the right cocktail for the respective samples. You'll find a selection guide and an introduction to the "Do's and Don't's" of LSC written by James Thomson (Meridian Biotechnologies) on our web site in the LSC section.

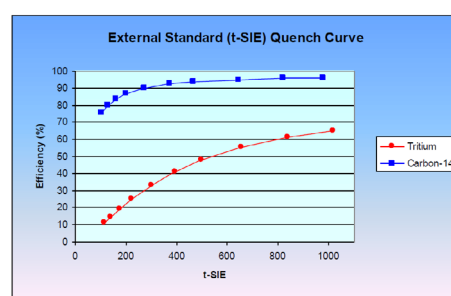
Each step of this energy transfer (from particle emission to photon detection in the PM) can be interfered through a variety of mechanisms and interactions and this is called quenching.



Quench will lead to spectral shift of signals towards lower energies and it will, depending on the energy of the emission, also impact detection efficiency, accordingly it is very important to correct for these quench effects. This is most frequently done by quantifying the quench level and the use of so-called quench curves. An overview on 'Quench and Quench curves' provided by James Thomson (Meridian Biotechnologies) can be found on our web site in the LSC section.



Influence of quench on LSC spectra. Taken from Hou¹



Examples of Quenchcurves. Taken from Thomson³

Very often it is possible, by thorough purification of the analyte, e.g. using extraction chromatography, to remove interferants and allow for having samples of very similar chemical composition thus avoiding or limiting the necessity of using quench curves.

APPLICATIONS

Liquid Scintillation Counting is particularly widely employed in radioanalytical chemistry and in radiopharmacy, usually in combination with suitable sample preparation steps such as separation chemistry and/or combustion using e.g. Raddec Pyrolyser unit (H-3, C-14, Cl- 36, I-129).

Its main application is the determination of beta emitters such as H-3, C-14, Sr-89/90, Pb-210, Ni-63, Cl-36, I-129... in a wide range of sample matrices such as environmental samples (water, soil, vegetation), biological samples (urine, blood) and decommissioning samples (concrete, steel, spent resin). It further allows for the determination of gross alpha and beta activity of water samples e.g. in the context of drinking water control.

In addition to its highly selective resins and their associated accessories TrisKem International also provides consumables for the preparation of samples for nuclear spectrometry, including Meridian Biotechnologies range of LSC consumables.

[1] Xiaolin Hou : "Liquid Scintillation Counting for the Determination of Beta Emitter — Principle and Application", http://www.nks.org/download/seminar/2009_radworkshop/NKS-B_RadWorkshop_8.pdf

[2] Steffen Happel: "Verfahrensoptimierung für die Bestimmung von alpha- und beta-strahlenden Nukliden in Wasser- und Bodenproben", PhD thesis, Marburg, 2003

[3] James Thomson : "Quench and Quench Curves", http://www.triskem-international.com/scripts/files/59bd7f0fe4c9f6.07016594/james_thomson_quench_and_quench_curves.pdf

PROSAFE+ COCKTAILS

ProSafe+

The ProSafe+ range is an improved version of the original ProSafe range. The solvent base has been changed from PXE to DIN and this has necessitated a minor change to the formulations. Overall the changes have produced cocktails with even higher Tritium efficiencies, better sample holding capacities and a guaranteed compatibility with commercially available quench sets.

ProSafe+ cocktails are high flashpoint, 100% biodegradable, high performance LSC cocktails. They are designed to be in accordance with the EC Directive 2003/53/EEC. ProSafe+ cocktails do not contain any Nonyl Phenol Ethoxylates (NPEs) or other Alkyl Phenol Ethoxylates (APEs) which produce endocrine disrupting metabolites upon biodegradation and are thus suitable for drain disposal, depending on radionuclide content of the counting samples and local radiation protection regulations.

Different ProSafe+ cocktails are available to cover a wide range of sample type counting.

ProSafe+ FC

High efficiency cocktail for use with wet and dry filters and lower volume (1 – 2 mL) of aqueous samples.

ProSafe HC +

High capacity cocktail accepting 10 mL of many dilute samples and lesser amounts of more concentrated samples in 10 mL cocktail.

ProSafe TS +

Specialist cocktail for use with solubilised (digested) samples originating from both organic and aqueous solubilizers.

ProSafe +

High performance cocktail accepting 4-6 mL of many dilute samples and lesser amounts of more concentrated samples in 10 mL of cocktail.



ProFlow G + - General Purpose

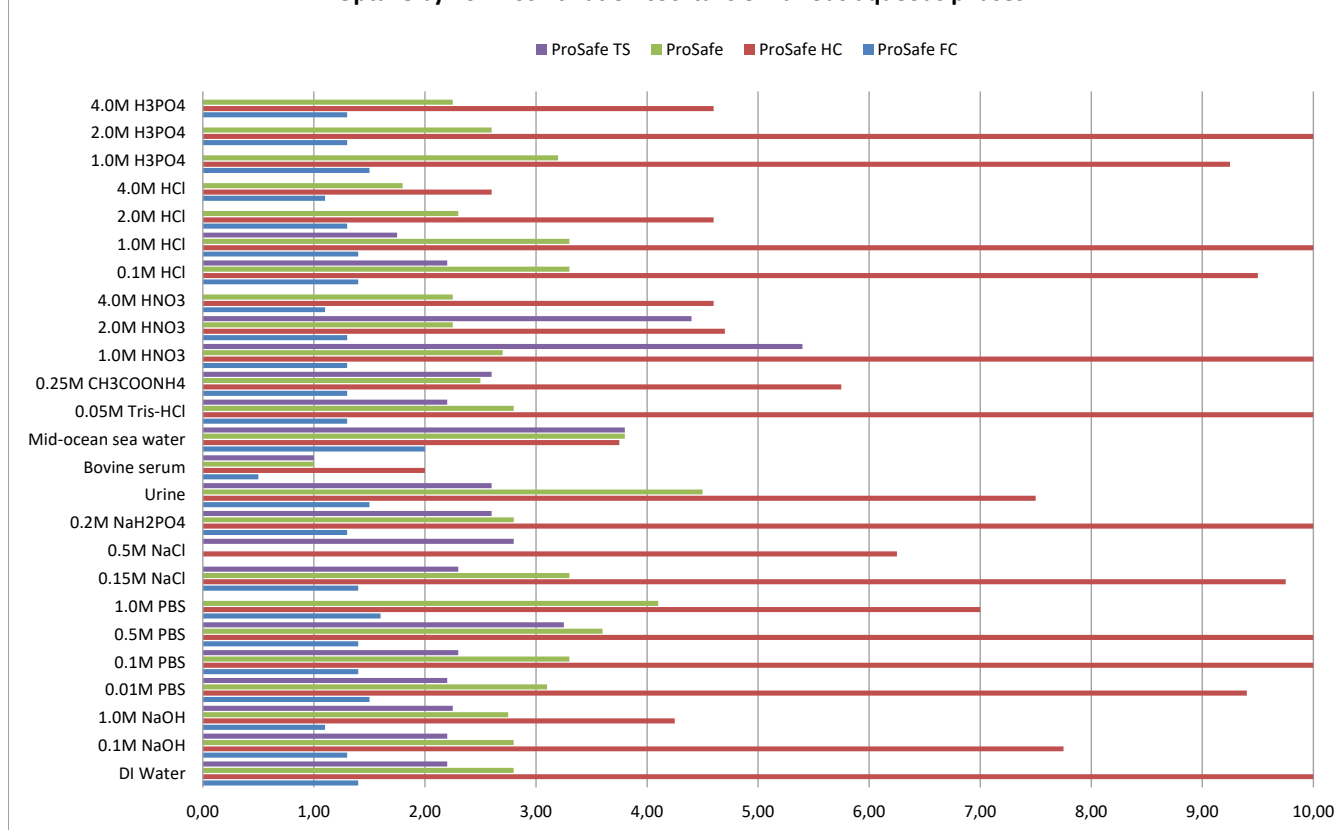
General purpose, non-jelling , flow cocktail with low viscosity (allowing easy mixing and pumping) for use with dilute eluents and organic/aqueous gradients.

ProFlow P + - Phosphate Gradients

General purpose non-jelling flow cocktail with low viscosity (allowing easy mixing and pumping) for use with 0 to 2M ammonium phosphate gradients.



Uptake by 10mL scintillation cocktails of various aqueous phases



STARGEL COCKTAILS

StarGel is a classical high flashpoint DIN based, biodegradable LSC cocktail specifically designed for suspension counting where the particulate matter is held in the gel phase. It is odourless and compatible with plastic vials. The cocktail shows very low quench with a tSIE of approximately 590 and a counting efficiencies of ~94% for C-14 and ~48% for H-3 under these conditions. It further shows a low background count rate of < 20 CPM in a 0 – 18.6 keV window (H-3). StarGel forms a stable gel with small amounts of water (2.3 – 2.5 mL per 10 mL StarGel) at 17° - 21°C. The cocktail contains NPEs and is thus not drain disposable.



ml water added to 10.0 ml Star Gel	17°C	21°C
0.00 ml	Clear	Clear
0.50 ml	Clear	Clear
1.00 ml	Clear	Clear
1.50 ml	Clear	Clear
1.50 ml	Unstable	Unstable
1.90 ml	Unstable	Unstable
2.00 ml	Gel	Gel
2.40 ml	Gel	Gel
2.50 ml	White gel	White Gel
>2.50 ml	Unstable	Unstable

GOLD STAR COCKTAILS

Gold Star cocktails are classical high flashpoint DIN based, biodegradable LSC cocktails designed for high sample capacity and counting efficiency. Gold Star cocktails contain NPEs and are thus NOT drain disposable.

Gold Star

High sample capacity, high counting efficiency cocktail for aqueous and organic samples. The Cocktail will accept 10 mL of many dilute samples and lesser amounts of more concentrated samples in 10 mL of cocktail.

Gold Star Quanta

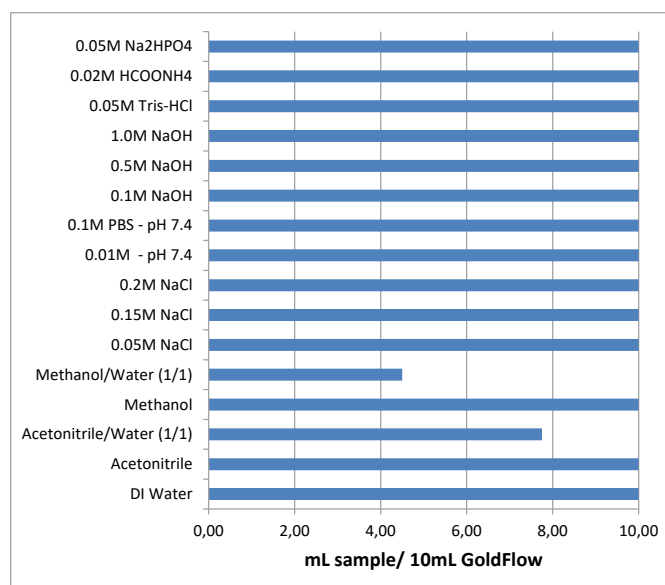
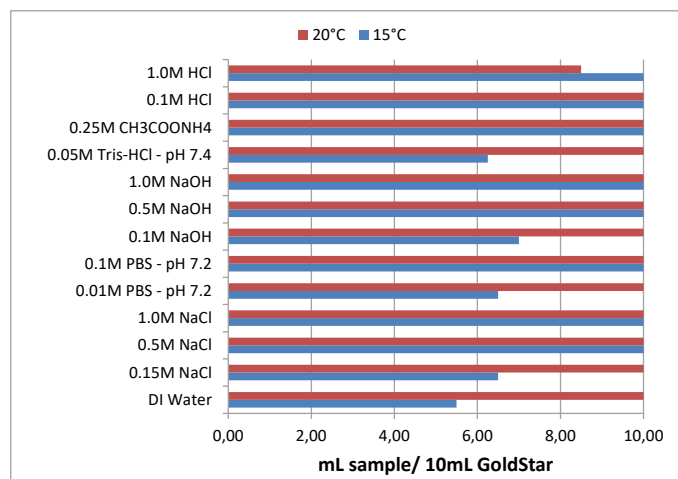
High flashpoint DIN based, biodegradable LSC cocktail that contain NPEs and that is thus not drain disposable.

It is a very high efficiency version of Gold Star that works with most dilute aqueous samples. It can accept up to 5.0 mL sample in 10 mL cocktail at 20°C and has even higher sample capacity at lower temperatures making it ideal for use with chilled LSC counters.

Gold Star Quanta gives approximately 55% Tritium efficiency unquenched and shows a low background count rate of < 20 CPM in a 0 – 18,6 keV window (3 H). It is thus very well suited especially for low level tritium measurements.

Gold Flow

Non-jelling, low-viscosity, high counting efficiency cocktail for Methanol / Water and Acetonitrile / Water gradients.



Gold Star LT² (Low Tritium @ Low Temperature)

Gold Star LT² is a high performance cocktail that will accept up to 12mL water in 10mL of cocktail. It has especially been designed for high water and urine capacity at various temperatures, including low temperatures, and high tritium counting efficiency, in order to allow its use, amongst others, for low level tritium measurement.

The cocktail can take up to 12mL of water samples with low matrix content (e.g. tap or deionised water) per 10 mL of cocktail at temperatures between 10°C and 20°C. For matrix rich water samples like sea water the uptake shows a very strong temperature dependency with low temperatures resulting in very high sample uptake.

Samples are stable even at 10°C and the cocktail shows no permeation through plastic vials, thus allowing extended-time counting which, in combination with its low background in an optimized Tritium window, allows obtaining very low detection limits. The cocktails can take up more than 3 mL of urine in 10mL of cocktail, nevertheless due to increasing quench with increasing urine volume it was found that 2.5 – 3 mL of urine in 10 mL of cocktail gave optimum performance.

The following figures compare the uptake of samples of various mineral acids and acid concentrations in Gold Star LT² and Gold Star; in general Gold Star LT² allows working at higher acid concentrations than Gold Star. The performance of Gold Star LT² in terms of background count rate, quench and MDA (minimum detectable activity) obtained was compared to the performance of Ultima Gold LLT and Ultima Gold uLLT; very similar results were found.

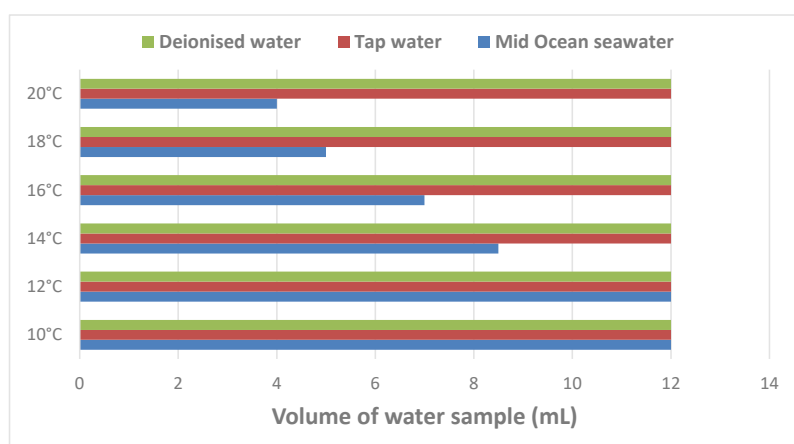


Low Level Counting Data Conditions A

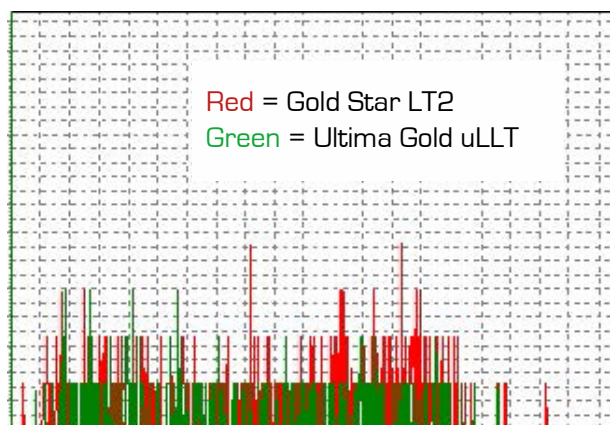
TriCarb 2550 TR
10 ml DI water
Low level count mode
0.5 – 4.5 keV window
300 minutes count time
Temp 11°C

Low Level Counting Data Conditions B

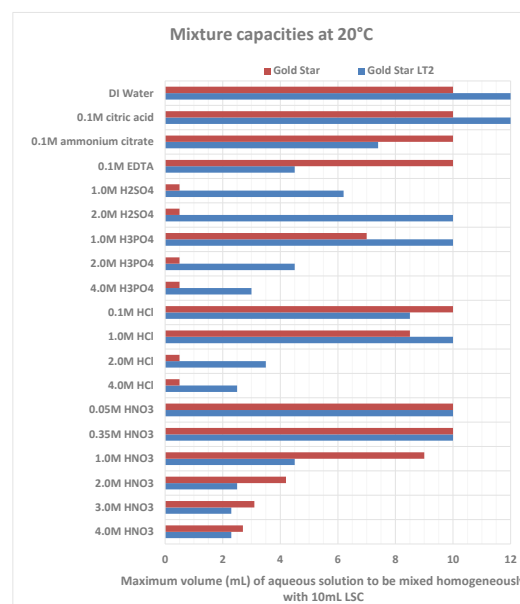
Quantulus
Channels 5-170 (optimised Tritium region)
10 ml DI water
600 mins count time
Temp 18°C



	Gold Star LT ²	Ultima Gold LLT
cpm	2.9	2.5
tSIE	285	285
MDA	0.29 Bq/L	0.27 Bq/L
LLD	1.53 Bq/L	1.43 Bq/L



Counting spectra comparison depending on LSC used



	Gold Star LT ²	Ultima Gold uLLT
cpm	0.84 ± 0.04	0.70 ± 0.03

The table hereunder shows the results of a series of experiments performed by James Thomson (Meridian Biotechnologies Ltd.) testing the maximum accepted volume of four liquid scintillation cocktails for aqueous solutions most commonly used for radionuclide elution from our extraction chromatographic resins.

Capacities @20° C	Gold Star	Gold Star LT ²	ProSafe+	ProSafeHC+
0.1M citric acid	10.0 ml	0.75 - 10.0 ml	3.25 ml	7.5 ml
0.1M ammonium citrate	10.0 ml	1.25 - 7.5 ml	2.75 ml	5.5 ml
0.1 EDTA	10.0 ml	2.25 - 4.5 ml	3.40 ml	5.25 ml
0.05M HNO ₃	10.0 ml	10.0 ml	3.75 ml	10.0 ml
0.35M HNO ₃	10.0 ml	10.0 ml	5.75 ml	10.0 ml
2M HNO ₃	4.25 ml	2.75 ml	2.75 ml	4.5 ml
3M HNO ₃	3.25 ml	2.25 ml	2.25 ml	4.25 ml
4M HNO ₃	2.75 ml	2.25 ml	2.50 ml	4.0 ml

RN COCKTAILS/ SOLUBILIZERS

Radon Cocktails

Radon cocktails are water immiscible LSC cocktails designed for the measurement of Radon in water after its extraction from the sample into the cocktail.

RadonCount - Pseudocumene based cocktail with a flashpoint of approx. 49°C.

ProScint Rn - Safer version of RadonCount based on a combination of mineral oil and pseudocumene with a flashpoint of approx. 65°C.

Solubilizers

GoldiSol - IPA based, Toluene and Methanol free non-toxic solubilizer.

Solubilizes tissues, tissue homogenates, whole blood and high water content samples such as plasma, brain and polyacrylamide gels. Does not froth when peroxide is added to decolorize the tissue digest, resulting in simple and easy decolorisation.

AquiGest - Aqueous based solubilizer (not classified as flammable or toxic).

Can replace organic solvent based solubilizers for a wide range of samples while providing equivalent or even faster dissolution. Resulting tissue digests are in general less coloured than digests obtained with organic solvent based solubilizers.



OXIDISER AND PYROLYSER SUPPLIES/VIALS

Oxidiser and Pyrolyser supplies

CarbonTrap - High capacity carbon dioxide absorber (CO_2 capacity: $4,8 \text{ mM} \cdot \text{mL}^{-1}$) used to trap radioactive carbon dioxide produced in sample oxidisers and pyrolysers.

CarbonCount - Specific cocktail for the counting of radioactive carbon dioxide captured in CarbonTrap.



Vials

Meridian plastic vials are manufactured from virgin High Density Linear Polyethylene (HDLP) ensuring uniformity of structure. Counting backgrounds are low (5-7 cpm in a 0-18.6 keV window) giving excellent performance. Using HDLP ensures no high flash point cocktails, such as Gold Star and Gold Star LT² permeate through the vial wall.

The vials are available in various sizes. For vials prepacked in trays, caps are delivered either screwed on the vial in separate bags.

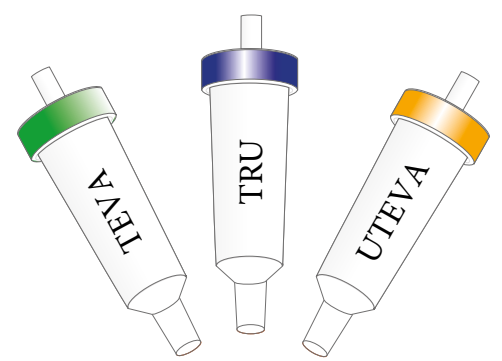
Meridian Glass Vials are manufactured with low background quartz materials with minimal detectable impurities. This ensures a performance benefits of low background (12-13 cpm in a 0-18.6 keV window) at low price. For user safety, the glass is annealed to prevent brittleness and minimize breakages. Vials are available in different packaging. Caps are packed separately in convenient bags of 100 and have a flat surface for writing or labelling.



Volume of vials	Qty prepacked in trays of 100	Caps
20mL	500	High reflection
20mL	500	Polycone
8mL	1000	PolyLined

Volume of vials	Qty	Prepacked in trays	In boxes	Caps
20mL	1000	-	yes	POPSCREW or PUSHIN
20mL	500	100/tray	-	
7mL	2500	-	yes	
8mL	2000 1024	256/tray	yes -	POPSCREW

Also available:
EXTRACTION CHROMATOGRAPHIC RESINS



Decommissioning

Determination of radionuclides in decommissioning samples

- Rapid Emergency Methods
- Rapid & reliable results
- Easy to handle
- High sample throughput
- Several analytes from one sample
- No toxic or dangerous reagents
- Difficult to measure radionuclides
- Decontamination of effluents

Radiopharmacy

Separation of radionuclides for medical applications

- Rapid, highly specific separation techniques
- Separation of radionuclides from irradiated targets
- Quality control of radionuclides for medical use
- Post-generator purification
- Radioprotection and Radioanalysis
- For use in glove boxes or hot cells

Environment

Determination of radionuclides in environmental and bioassay samples

- Rapid Emergency Methods
- Large Environmental Samples
- Various Matrices
- Separation of several elements out of one sample
- Fast methods and reliable results

Geochemistry

Efficient separation of cations for ICP-MS analysis

- Dating & isotope ratio determination
- Preconcentration & matrix removal
- Removal of isobaric interferences
- Fast methods and reliable results
- Separation of several elements out of one sample

COCKTAIL EQUIVALENT CHART:

Meridian	PerkinElmer
ProSafe ⁺	Ultima Gold / Hi-Safe 2
ProSafe HC ⁺ / Gold Star	Ultima Gold XR / Hi-Safe 3
ProSafe FC ⁺	Ultima Gold MV / Supermix / Filter-Count
ProSafe TS ⁺	Hionic Fluor
ProSafe G ⁺ /Gold Flow	Ultima-Flow M / Opti-Flow Safe I
ProSafe P ⁺	Ultima-Flo AP / Ultima-Flo AF
RadonCount	Insta-Fluor Plus / OptiScint Safe
ProScint Rn	Ultima Gold F / Scint Hi-Safe / High Efficiency Mineral Oil Scintillator
StarGel	InstaGel
Gold Star LT2	Ultima Gold AB / Ultima Gold LLT / Tri-Safe
Gold Star Quanta	Ultima Gold AB / Ultima Gold LLT / Tri-Safe
CarbonCount	Permafluor E+ / Optisorb-S
CarbonTrap	Carbosorb E / Optisorb-1
GoldiSol	Soluene-350 / Optisolve
AquiGest	SOLVABLE
Hyamine hydroxide	Hyamine hydroxide



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