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MAINTENANCE OF TISSUE SIMULATING LIQUIDS AND GELS

1 COMPOSITION OF TISSUE SIMULATING LIQUIDS AND GELS

Tissue simulating liquids and gels are based on a mixture of water with other components. Target parameters for the permittivity and conductivity of tissue simulating liquids and gels as well as sample recipes are given in the standards.

A concentration of at least 95% water is used for all saline solution to achieve the desired permittivity at an environmental temperature of 22°C. In addition to water, cellulose is used for thickening liquid to gel without decreasing the permittivity below the required values.

The following components are commonly used, but different chemicals are possible:

- **Water** dionized water, main ingredient for all liquids and gels
- **Sugar** used for frequencies >300 MHz
- **POEM** polyoxyethylenesorbitan monolaurate
- **Oil** with emulgators

Further, minor additives serve the following purposes:

- **NaCl** for increasing the conductivity
- **Cellulose** for thickening liquid to gel
- **Preservative** for preventing the solutions from degrading due to bacterial and fungal growth

During the usage of tissue simulating liquids/gels, with a large surface area exposed to the air, mainly water evaporates, other liquid/gel ingredients evaporate to a much lower extent. Solid ingredients and other additives will rarely evaporate and rather tend to cling to the phantom surface or the edges.

As a result of the water evaporation, the dielectric parameters will change with exposure time. Depending on the liquid/gel type, it also influences the conductivity. Permittivity will decrease and need to be corrected to the target values (within the required tolerance). Note that apparent differences might also result from poor dielectric parameter measurements: permittivity may appear lower, e.g. if air bubbles or an oily layer are present. Add de-ionized water to re-establish the permittivity according to the following rules:

- Measure the liquid/gel parameters and calculate the deviation from permittivity and conductivity. Be aware of your measurement uncertainty, the effect of the temperature gradients and the quality on your results.
- Calculate the required amount of missing water (in percentage of the total weight) to obtain the desired permittivity. The permittivity can be measured with higher reliability than conductivity and is dominantly affected in most cases. Be aware that the conductivity may change in either direction with the evaporation, depending on liquid/gel type and frequency.
- If you are not experienced, use a liquid/gel sample for any kind of correction. At first add 50% of the amount required for correction to the liquid and mix it well.
- Repeat the measurement, verify the effect and calculate the figures for further correction.

Be aware that the parameters will also change with temperature. The temperature sensitivity of permittivity and conductivity depend both on the liquid/gel type and the frequency. It is usually higher for conductivity. It is assumed that liquid/gel parameters are measured at the nominal temperature.

Solid material contaminants like hair, dust, etc. may be filtered out if needed. Before using samples for measurement, make sure the liquid/gel is homogeneous so that it represents the necessary average characteristics.

It is also important to homogenize the liquid before returning it into its storage container in order to maintain these average characteristics.

2 SUGAR BASED LIQUID

Preservative is contained in this type of liquid to suppress bacterial and fungal growth. After storage as well as between periods of usage, the liquid can become inhomogeneous due to the heavier sugar settling at the bottom and near surfaces. If the liquid begins to become lumpy after a very long storage time, heating and stirring is recommended to re-dissolve the lumps. Otherwise, stirring is sufficient for homogenization. Shaking will lead to air bubbles, which may require considerable time to dissipate; foam may need one or more hours to disappear.

The **sensitivities to water addition** (parameter increase per weight added) of this sugar based tissue simulating liquid at the frequencies of interest are typically in the following range:

HSL300V2: permittivity +0.88%, conductivity +1.55% per % of water

If it is not possible to correct the liquid solely by adding water, other measures should be taken after verifying their effectiveness on a sample.

- Adding Sugar will have the inverse effect of adding water. To dissolve the sugar, a long stirring time and preferably elevated temperature is required. Alternatively, it may be easier to leave the liquid in an open phantom for some time during which time water will evaporate.
- Adding NaCl will mainly increase the conductivity. Permittivity may also be influenced by higher or lower values. Note that NaCl will usually not be missing.

3 OIL / POEM BASED LIQUIDS

Oil / POEM based liquids are an emulsion of a complex mixture of ingredients and it contains only a small percentage of water. Their appearance is yellow-brown transparent. Before using or handling the liquid, it must therefore be stirred to become entirely homogeneous. An opaque appearance is possible but will not influence the dielectric parameters if it is homogeneous during the measurement at the probe surface.

Regarding correction, evaporation of water is most probable, but salt will not evaporate. Therefore only de-ionized or distilled water shall be added - and only if based on a reliable measurement.

Evaporated water can be replaced and that will lead to a **increase** of the permittivity and to a major extent to the conductivity. Corrections should therefore be made in several steps. Reduction of the water content is only possible by evaporation in a container or phantom with a large surface area exposed to air. Dielectric measurement probes require a fully homogeneous material for the measurement in front of the probe. They are more sensitive to the material in the immediate vicinity of the active probe area. Thus it becomes clear that when measuring inhomogeneous liquids, the measurement is not representative due to the contacting and close layers containing less water and being less conductive. Therefore at first the measurement has to be verified with a well homogenized and representative sample.

Storage is recommended in the closed containers in dark environment and at low temperatures (10 - 20 °C). Avoid freezing and high temperatures > 25 °C.

During operation of the liquid, it shall be stirred regularly. If exposed for longer time to air, a jelly-like phase may deposit at the air / phantom interface and must be re-mixed and into the liquid with a soft spatula and fully dissolved. The same applies for deposits on field probes. The top layer tends to evaporate water leading to a skin or layer with less water. When idle for longer time, it might tend to separate, and then the water tends to move downwards.

The **sensitivities to water addition** (parameter increase per weight added) of Oil / POAM based tissue simulating liquids at the frequencies of interest are typically in the following range:

TLe11.5c.045@xx: permittivity +3.80%, conductivity +9.2% per % of water

Parameter values increase based on water addition are high due to the low water content of the mixture. Long stirring time is required, make sure that the liquid is homogeneous and that no residual particles are visible.

Disposal of oil-based liquids must not be in the environment or in the sewage or wastewater. Use disposable paper towels to clean surfaces before final washing of equipment with soapy water.

4 SALINE WATER

Saline water is a simple mixture of ingredients. Their appearance is transparent, using or handling of saline water is easygoing, even maintenance or correction pretty straight forward.

Evaporated water can be replaced and that will lead to a **decrease** of the conductivity whereas adding salt will **increase** the conductivity. Note that NaCl will usually not be missing. Corrections should be made in several steps.

The **sensitivities to water addition** (parameter increase per weight added) of saline water at the frequencies of interest are typically in the following range:

TLe78cx.xx@64: permittivity +0.0%, conductivity -1.0% per % of water

5 SALINE-HEX GELS

Cellulose (hex) is used as thickener agent to saline water. Their appearances are transparent with a yellowish tinge. Usually replacing evaporated water is sufficient for maintenance. If it is not possible to correct the liquid solely by adding water, add saline water with appropriate salt content into the mixture. Stirring is time consuming, water or salt-water (salt has to be solved in water **before** the mixture) is relatively hard to get into the gels. The stirring process can take up to 30 minutes.

Evaporated water can be replaced and that will lead to a **decrease** of the conductivity whereas adding NaCl will **increase** the conductivity. Note that NaCl will usually not be missing. Corrections should be made in several steps.

The **sensitivities to water addition** (parameter increase per weight added) of saline-hex gels at the frequencies of interest are typically in the following range:

TGe78cx.xx@64: permittivity +0.0%, conductivity -1.0% per % of water