PRECISION ACOUSTICS
A Coda Octopus Company

USER GUIDE

Tissue phantom kit – User guide and mixing Instructions

This document contains guidance on how to make a tissue-mimic material from the Precision Acoustics kit.

The lab hardware required for the manufacturing process is not contained within the kit and must be made available to the user through other means. A list of suggested requirements can be found within this document in Section 2, Table 3.

Health and safety considerations are outlined in the instructions, however a full understanding of the handling requirements of the material components of this kit should be gained before use from the Material Safety Datasheet (MSDS) documents. Materials should be handled in accordance with the user's local institutional requirements. Further information is available through our website.

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1 KIT CONTENTS

1.1 KIT TMM-001L

Component	Quantity
Distilled Water (< 5 µS/cm)	5000 g
Glycerol	700 g
Silicon carbide (SiC (-400 mesh))	32 g
Aluminium oxide (Al2O3 (0.3 µm))	53 g
Aluminium oxide (Al2O3 (3 µm))	57 g
Agar	182 g

Table 1. Contents of kit TMM-001L

1.2 KIT TMM-001S

Component	Quantity
Distilled Water (< 5 µS/cm)	2500 g
Glycerol	350 g
Silicon carbide (SiC (-400 mesh))	16 g
Aluminium oxide (Al2O3 (0,3 µm))	27 g
Aluminium oxide (Al2O3 (3µm))	29 g
Agar	91 g

Table 2. Contents of kit TMM-001S

2 ADDITIONAL EQUIPMENT REQUIREMENTS

Property	Value
Glass beaker	Suitable for heating to 90°C. Capacity: as required.
Glass stirring rod	Glass preferred to minimise thermal conductivity. Alternatively stainless steel.
Hotplate stirrer or heated water bath	Suitable for warming to 90°C. Magnetic stirrer recommended.
Mass balance	With suitable precision. Accuracy of 10 mg recommended.
Temperature probe or infrared thermometer	Accuracy of +/-1°C recommended.
Plastic film (Cling Film, Saran Wrap)	For sealing beaker lids to prevent evaporation.
Mould	For casting the phantom material to shape
Benzalkonium Chloride (0.5% w/w)	Optional. For increased longevity of set material.

Table 3. List of recommended hardware.

3 FORMULATION

The table below sets out the relative weights of the material components required to make 100 g of tissue mimic material. For larger volumes, the weights can be scaled accordingly. It is not recommended that a weight under 100 g is mixed, to preserve accuracy of the formulation.

With a density of around 1043 kg/m^3, 100 g of mixed material will occupy a volume of approximately *95.9 cm^3.*

Component	**Quantity required to make 100 g of tissue mimic material**
Distilled Water (< 5 µS/cm)	***83.34 g***
Glycerol	***11.26 g***
Silicon carbide (SiC (-400 mesh))	***0.53 g***
Aluminium oxide (Al_2O_3 (0.3 µm))	***0.94 g***
Aluminium oxide (Al_2O_3 (3 µm))	***0.88 g***
Agar	***3.03 g***

Table 4. PA tissue mimic recipe.

Note: If adding Benzalkonium Chloride, this should be done to a weight of 0.47 g per 100 g of material.

Please Note:

All components must be accurately weighed according to the formulation table, even when using the full contents of the 2 litre or 5 litre kits.

It is recommended to mix 10% additional material above what is minimally required to allow for residual material in the mixing equipment and ensure moulds can be filled completely.

Moulds should be prepared and cleaned prior to mixing to allow timely casting of the material after the mix is complete.

For TMM batches larger than 500 ml, a mechanical stirrer and a water bath are recommended, as larger volumes heat and cool slowly on a hotplate and are not stirred as effectively by a magnetic bar.

The acoustic and physical properties of the finished material will be dependent on the accuracy of the mixture.

4 SAFETY PROTOCOL

Please read the necessary material safety data sheets and take all the necessary safety precautions prior to opening the kit. This kit is designed for professional use only. Materials should be handled in accordance with your local workplace regulations.

5 PROCEDURE

1. Prepare a mould for the tissue phantom.
2. Calculate your mass requirements of the individual ingredients using the information in the formulation section of this guide, table 4.
3. Using a calibrated scale with suitable resolution, weigh the required volume of deionised water into a clean vessel that is suitable for your mixing method (eg: glass beaker).
4. Pre-heat the water to between 80 and 90 °C using either:
    a. A hotplate, or
    b. A water bath or
    c. Other appropriate method
5. In a separate clean and dry vessel, accurately weigh and combine the following components (to a precision of 0.01g):
    a. Aluminium oxide (Al_2O_3) - Both particle sizes
    b. Silicon carbide (SiC)
    c. Glycerol

    Note: This vessel should have sufficient volume to comfortably hold the entire volume of tissue mimic material being made.
6. If using Benzalkonium Chloride add this to the mixture at this step.
7. Stir the powder mixture using a clean, inert stirring rod—either metal or glass. Continue stirring until it becomes a homogeneous, light grey, viscous paste, ensuring all clumps of powder are thoroughly broken up during this stage.
8. Weigh the required amount of Agar powder into a third vessel.
9. Add the agar and the preheated water directly into the vessel containing the Aluminium Oxide, silicon carbide, glycerol paste.
10. Mix thoroughly until the mixture is completely smooth and uniform.
11. After mixing, cover the vessel with an appropriate lid to minimise evaporation.

    Note: Flexible plastic wrap or film is recommended for glass beakers. The lid should allow for access with a temperature probe, if a temperature probe is being used to monitor the temperature of the mixture.
12. Place the mixture on the hotplate or heating bath and stir the mixture to maintain homogeneity.

    Note: If using a magnetic stirrer, a speed of 200 rpm has been found to work well, but the required speed may vary depending on the make/model of the equipment.
13. Reach and maintain a temperature of between 80 and 90 °C whilst stirring the mixture.

    Note: A temperature probe or non-contact infrared thermometer are recommended for the monitoring of temperature at this stage. The speed of the stirrer may need to increase as the temperature of the mixture thickens.
14. Do NOT allow the mixture to reach 100 °C as this can introduce air bubbles and compromise the quality of the final product
15. Maintain the temperature in the 80 to 90 °C range for 1 hour whilst stirring.
16. After 1 hour, allow the mixture to cool to 47 °C.
17. Adjust the stirring speed as needed to prevent the formation of a vortex in the solution.
18. Once the mixture reaches 47 °C, remove any stirring equipment from the vessel and pour the solution into the prepared mould.

Note: To pour the fluid without incorporating air, tilt the receiving container slightly and pour the fluid slowly down the side, maintaining a steady, controlled flow to avoid splashing or turbulence.

19. Once filled, cover the mould to prevent water loss and allow to cool.
20. Leave for 24 hours to allow the material to set.
21. After 24 hours, demould the phantom—it is now ready for use.

If correctly made, the tissue mimic material will have a light grey appearance as figure 1. And physical and acoustic properties will be comparable to the technical datasheet supplied by Precision Acoustics.

Figure 1. Showing the appearance of a correctly formulated tissue mimic material.

6 STORAGE

The finished tissue mimic must be stored in a sealed container or wrapped to prevent air exposure to its surface to ensure the acoustic properties are maintained.

The finished tissue mimic material has a shelf-life of 1 week after mixing if stored appropriately at room temperature.

Do not store the tissue mimic in water. If the finished tissue mimic is stored in water, the glycerol will leach out, altering the wave speed. If exposed to air, the water will evaporate, causing the phantom to shrink also affecting the wave speed. A glycerol-water mixture can be used for storage if preferable to an air-tight container, as described in IEC 60601-2-37:

"The material should be stored in a closed container under normal laboratory conditions (18 °C – 25 °C). While stored, keep the material in a water/glycerol mixture to prevent it from drying out and to avoid air contact. This mixture contains 88.1 % (weight) demineralised water and 11.9 % (weight) glycerol (purity >99 %)."

7 REFERENCES AND ADDITIONAL INFORMATION

[1] *IEC 60601-2-5:2015 Particular requirements for the basic safety and essential performance of ultrasonic physiotherapy equipment,* 2015.

[2] *IEC TS 63081:2019 Ultrasonics - Methods for the characterization of the ultrasonic properties of materials,* 2019.

[3] *IEC60601-2-37;2024 Particular Standard for Safety of Ultrasonic Medical diagnostic and monitoring Equipment,* 2011.

[4] *R M Souza et al. "The importance of proper storage of agar phantom on the water-glycerol-benzalkonium chloride mixture to maintain the ultrasonic group velocity", J. Phys.: Conf. Ser. 2606 012012, 2023*

[5] *R M Souza et al. "Standard operating procedure to prepare agar phantoms" J.Phys.: Conf. Ser. 733 012044, 2016*

8 CONTACT

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