Chapter 9: Recipes

The ingredients used for concocting the objects throughout this book vary. Different material formulations were generated specifically for each material, and refined for their performance, flowability, adhesion, precision and strength. Developing the constituents for each recipe has been a lengthy process that requires much trial and error. Nevertheless, anyone can create their own powder materials for 3D printing. Many companies and schools around the world own powder-based, binderjet 3D printers (often this is of the unsupported, Z-Corp, brand), however, the proprietary materials (powders and liquid binders) associated with these printers can be very expensive. These types of printers are quite simple devices and employ an additive manufacturing process that deposits a binder material onto a thin layer of powder.

The liquid binder used in binder jet 3D printing is sprayed from an inkjet printhead (hence 3D printing). Printheads are the same as those used in “2D” printers, but the 3D printer pushes out all the “2D” black ink, which would normally be used to print images or text, and replaces it with a liquid binder that fuses the powder particles together. Because the liquid is comprised mostly of water, it is easy to use other water-based materials in its place.

Here are a few quick recipes\* to jumpstart the process of making open source liquid binder and powder mixtures materials for binder jet additive manufacturing.[[1]](#footnote-1)

\*Disclaimer:

The contents of these recipes have been successful for the authors of this book, and are true and complete to the best of our knowledge. All of the recipes are made without guarantee on the part of the authors or publishers of this book. The author and publisher disclaim any liability in connection to the use of these recipes.

Liquid Binder Recipes:

Rice Wine Binder

If you aren’t in the mood for cooking, the easiest binder to use is Sake Rice Wine right out of the bottle. Inexpensive, unflavored and uncolored is best. You may try a few brands, but make sure there are no particles in the liquid and that it is distilled clean and clear (15%-20% alcohol). You can open the bottle and pour it right it the binder reservoir. When running the purge cycle to remove the black ink from the cartridge, you may get an overheat error, but simply re-run the purge cycle again. Once you begin printing, you will notice a beautiful aroma of rice wine filling the air as you print.

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### Alcohol and Water Binder

A simple recipe for binder requires only two ingredients:

Drugstore Brand 91% Isopropyl Alcohol – 280 ml

Distilled Water — 920 ml

Method:

1.Mix alcohol and water in a container.

2. Shake or stir as preferred.

3. Pour into the binder chamber and serve.

Powder Recipes:

Sugar-Sugar Powder

If your sweet tooth beckons, here is a recipe for 3D printing sugar. It can be printed with either binder, and the results are just as sweet. There are only two ingredients in this sugar recipe: sugar and sugar.

Ingredients:

White Satin Baker’s Special Sugar – 200 units

Powdered Sugar (10x or 12x) – 100 units

Method:

1. Mix the white satin sugar and the powdered sugar together in a large container.

2. Fill the supply bed of the 3D printer with the sugar mixture.

3. Purge the black ink from the printhead and fill the supply reservoir with rice wine.Experiment with spraying different binder saturation levels and material layer thicknesses. Settings vary from printer to printer and location depending on ambient humidity. A good technique for testing is to make 5mm X 5mm X 150mm bars. Print them and see if the previous layer appears through the current printing layer. If so, it means the two layers are receiving enough binder and are fusing together.

4. Use established settings to print final object.

5. Wait 24 hours to excavate and depowder final object. Use machine recommended setting and techniques for excavating.

6. Post process with cyanoacrylate, polymer or wax for strengthening, or don’t.

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### Salt Powder

If you aren’t in the mood for sweets, here is something savory—a recipe for 3D printing salt.

Ingredients:

Finely Powdered Salt — 8 parts by weight

Maltodextrin — 1 part by weight

Method:

1.Purchase finely ground powdered salt, if it is not available, grind the salt in a coffee grinder and sift through 60, 100 and 120 mesh screens until the salt looks like white dust.

2. Screen salt dust through 150 mesh screen.

3. Mix the finely ground salt with the maltodextrin, either by shaking in a large, closed bucket until evenly distributed, or with a drill mixer. Remember to do so only in a well ventilated area and protect yourself by wearing a dust mask or respirator.

4. Purge the black ink from the printhead and fill the supply reservoir with rice wine.

5. Experiment with spraying different binder saturation levels and material layer thicknesses. Remember, settings can vary from printer to printer and in different climates depending on ambient humidity.

6. Use established settings to print final object.

7. Wait 24 hours to excavate and depowder the final object.

8. Post process with cyanoacrylate, polymer or wax for strengthening, or leave natural.

### Terra Cotta Slip

This is a recipe for 3D printing ceramics that can be fired in a kiln.

Ingredients:

### Terracotta powder – 1000 units

Powdered Sugar ———– 250 units

Maltodextrin ————- 250 units

Method:

1. Mix the terracotta, powdered sugar and maltodextrin together in a large bucket. This can be done by placing the lid on the bucket and shaking vigorously, or, in a well ventilated area, mix with a drill mixer. (This will produce dust, so a dust mask and proper ventilation is necessary because inhaling terracotta is dangerous.)

2. Carefully fill the supply bed of the 3D printer with the terracotta mixture (remember to turn on ventilation and wear a dust mask or respirator).

3. Purge the black ink from the printhead and fill the supply reservoir with rice wine instead of the proprietary binder.

4. Experiment with spraying different binder saturation levels and material layer thicknesses. Settings vary from printer to printer and in different climates depending on ambient humidity.

6. Use established settings to print final object.

7. Wait 24 hours to excavate and depowder the final object.

8. Bisque fire green porcelain part for strengthening.

9. Glaze to taste.

10. Fire to full temperature recommended by clay supplier.

Enjoy!

DIY recipes:

There are several steps you should try if you’d like to invent other materials for powder based 3D printing. Below is a guide to several steps we undergo when inventing a new material.

Bench testing:

Bench testing is used to verify the correctness or soundness of the material formulation.

1. Mix small batches of different ingredients in parts in a small cup, for example 2 parts sugar to 1 part powdered sugar.

2. Pour the batches out on a flat surface, in small piles, and flatten each pile with a spatula or rolling pin.

3. Spray liquid binder on the top surface of the flattened ingredients, using a small spray bottle, then leave the mixture to rest for 24 hours.

4. Examine the top layer of the mixture that was sprayed with binder. If it is stiff, hard, solid, and distinct in strength from the loose powder below, you are on the right track to inventing a material. If it crumbles, then it is too weak and the ingredient ratios need to be adjusted (add more sticky stuff). [Figure 161] [Figure 162] [Figure 163]

Test Bars

Test bars are used to make small prints that allow you to examine the strength and accuracy of the material, as well as for you to adjust the binder settings. When bench testing has resulted in a formula that shows promise, move to the 3D printer, to print test bars using your new recipe.

1. Fill the supply bed in a powder based printer with 3” of the material formulation.

2. Make test bars that are 5mm x 5mm x 150mm.

3. Test different layer thicknesses and saturation level settings in the zprint software (or other software if you are not using a zcorp powder printer). If the saturation levels are too high the powder within the printed portion of the bar will smear outside the bar boundaries.

4. Remove the printed bars by raising the build bed in the printer and brushing off the loose powder surrounding the bars. If the bars are solid to the touch and are not warped or crumbly, then the print has been successful. If the bar crumbles then repeat the process with greater saturation levels. If the bar is warped, repeat the process with lower saturation levels.

5. Dip or brush the bar with wax, polymer or cyanoacrylate to process, or enjoy raw! [Figure 164] [Figure 165]

Developing ones own materials for 3D printing opens the door to new material possibilities and combinations. Some of the advantages of printing with one’s own materials include reduced cost, new color variations and textures, and having the ability to use local and recycled materials.

The objects below are 3D printed in a combination of curry and cement, and chardonnay and cement, two customized recipes using off the shelf materials, that demonstrate the ease of creating evocative, multi-sensorial objects using 3D printing. The aromas of the curry and the chardonnay as they are being printed are pervasive and reminiscent. By employing 3D printing to make physical new material recipes, the objects, building components, spaces, and structures that are formed will engage the visual, haptic, and olfactory senses, as well as possess extraordinary geometric complexity. This process also raises important questions about the historical and contextual meaning of objects, as well as very simple ones, like, why curry and concrete? When such questions are asked of objects, it leads to creativity and speculation about the possibilities of contemporary craft. As pointed out by Gareth Williams, “In order to retain relevance in the modern world, craft must engage with contemporary concerns. One of the most pressing issues today is the impact of production, consumption and disposal of goods upon the earth’s resources and ecological balance.”[[2]](#footnote-2) 3D printing also raises questions about its role in craft as the objects produced are not necessarily handmade objects, however the close connections between design, iteration, technique, material behavior, and analysis, and manufacturing suggest that 3D printing, especially when coupled with modes of production that employ materials from sustainable resources and waste streams, is a contemporary form of craft with increasing relevance. And if we also draw from the craft traditions of the past when speculating about the future, the emerging objects from this nascent technology that inform, shape, and imbue meaning to future forms of architecture will have lasting value in contemporary culture.

[Figure 166] [Figure 167]

1. The recipes suggested here are adapted from and courtesy of the Recipes for Powder Printers Wiki available under [GNU Free Documentation License 1.2](http://www.gnu.org/copyleft/fdl.html). http://reprap.org/wiki/Powder\_Printer\_Recipes [↑](#footnote-ref-1)
2. Gareth Williams, “Creating Lasting Values,” in *The Persistence of Craft: The Applied Arts Today*, ed. Paul Greehalgh, (Piscataway: Rutgers University Press, 2003), 61. [↑](#footnote-ref-2)