

## NIELLO: AN INTRODUCTION TO AN ANCIENT MATERIAL FOR THE MODERN JEWELER

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#### INTRODUCTION

From ancient times until the end of the Renaissance, niello was a common alloy used by jewelers. Niello is a metal sulfide, usually composed of silver, copper and lead sulfides. Its strength in jewelry is as a high-contrast, fusion-inlaid alloy. The combination of low working temperature and fusibility makes it very easy to work with. Its deep black color permeates the alloy, making it an excellent choice for high-wear items.

My introduction to niello came at the turn of the century while researching medieval jewelry and metal work. The jewelers I knew were aware of niello as a historical technique and its advantages as a high-contrast inlay. However, there was a reticence to work with niello due to its lead content and toxic preparation.

In 2012 I was looking for a way to render the marble patterns I discovered while touring India (Figure 1). I wanted to translate the patterns onto the barrels and caps of fountain pens. Due to being handled constantly, patination was impractical. I pulled out my copy of Cellini's *Treatise on Goldsmithing and Sculpture*,<sup>1</sup> and within weeks of returning from India I was making my first batch of niello. I don't recommend following my path of using an intricate object as your first experiment in niello. A cylindrical piece with a fair bit of mass is a challenge when fusing niello, but after a few weeks of experimenting, I was able to finish a pen inspired by some marble work at the Red Fort in Jaipur (Figure 2). What follows is the knowledge gained during my experiments with niello over the past five years.



Figure 1 Marble pattern from the Red Fort in Jaipur, India



Figure 2 Jaipur pen by author in Argentium® silver and niello

#### HISTORY

Pieces as old as 3500 years have been found with niello in them. There are traditions of niello work in many cultures up until the end of the Renaissance. Post Renaissance, it was still common in Russia and parts of Asia. The peak of its use was in Italy during the late medieval and Renaissance periods. Niello was important enough to goldsmiths in Renaissance Italy for Cellini to open his *Treatise on Goldsmithing and Sculpture*<sup>1</sup> with a chapter on its preparation and use. Its use since the beginning of the 20th century has primarily been limited to Russia and Thailand.

Throughout history, recipes for niello have varied. Everyone who has written about it has their own particular recipe and method of preparation. The earliest written reference to a recipe for niello appears in book 33 of Pliny the Elder's *Natural History*.<sup>2</sup> He makes reference to ancient Egyptians staining silver with sulfur, although it looks like this is a process of blackening silver using liver of sulfur. The recipe he provides for niello contains silver and copper but lacks lead, making it difficult to work with compared to more modern recipes with a lower melting temperature. As the higher melting temperature would break down the sulfides, it would be applied at a lower temperature as a hot, soft paste. The Romans were fond of using niello on bronze. The higher melting temperature of the bronze made it easier to work with the higher-temperature niello.

Sometime in the early Middle Ages, the addition of lead to reduce niello's melting temperature gained popularity. By the time niello is discussed in *Mappae Clavicula*<sup>3</sup> in AD 600, lead is a staple in all recipes and will remain so. Its addition sufficiently lowers the melting temperature of niello to where it can be applied as a liquid without breaking down the sulfides. The 12th century German monk Theophilus Presbyter discusses the preparation and two methods of application in *On Divers Arts*.<sup>4</sup> The discussion centers around making a chalice, and the application methods are virtually unchanged from what I use today.

When looking for early examples of niello work, keep an eye out for pieces labeled as having black enamel in them. Many pieces are mis-catalogued as one when the other was used. Both black enamel and niello can break down over time, and they often appear very similar when degraded. A proper analysis of the material is required to know with certainty which was used. While often mistaken for the other, niello and enamel should not be used together in the same piece. Regardless of the original material used, enamel or niello, both provide excellent examples of how to create effective designs for niello. Enamel work in general is an excellent source of design ideas. Champlevé, basse-taille, and cloisonné techniques are all effective when niello is substituted for enamel.

#### SAFETY

There are several safety concerns when working with niello. Because of the lead content and burning sulfur during preparation, niello can present both short- and long-term dangers. However, niello can be safe to work with if you take proper precautions.

While preparing niello, all normal precautions should be taken while working with torches and high heat. In addition to working with high-temperature metals, you will also be working with lead and sulfur. A full-face respirator is a critical piece of equipment while preparing niello. The preparation will involve melting lead, and there is a possibility of the lead vaporizing. You will also be pouring the molten alloy into sulfur, which will catch on fire and create noxious fumes. The fumes will attack your eyes and your throat; therefore, a respirator with a P100 cartridge is important. The preparation should be done outside, away from people, or inside an effective fume hood. If you do not have a good- quality ventilation setup, a link is provided in the Reference section on how to create one sufficient to work with niello.<sup>5</sup>

After the initial preparation of the niello, the risk of working with niello decreases. However, you will still be working with molten metal and with dust containing lead. Eating and drinking in the studio is a bad idea no matter what materials you work with; however, many jewelers still do it. If you eat or drink in the shop regularly, avoid it while working with niello. After inhalation, ingesting lead is the next most effective way for it to enter your system. Keep your hands away from your face, and thoroughly clean them after working with niello. While filing or sanding, use either ventilation or a mask to prevent inhaling the dust. I use inexpensive nitrile gloves when working with niello. They are an easy way to reduce the clean-up of my hands (it is still important to wash your hands afterward). Be aware of contamination of your clothes as well. I have clothes I only wear in the studio, and amongst them, I have clothes I only wear while working with niello. All clothes contaminated by niello are washed separately from the rest of my clothes.

In addition to protecting yourself from lead contamination, it is important to protect the rest of your studio as well. Any catch trays should be thoroughly cleaned before and after working with niello. You should also have a set of tools for working specifically with niello. Files, sanding sticks, and polishing accessories Manning

are particularly important to keep segregated. Any lead contamination of precious metals can lead to disaster if they are heated to soldering temperatures. Small pits will form in your work where the lead dust alloys with the precious metal. In most cases removing the pits will destroy the work. While sanding niello, working wet will significantly reduce the chances of dust contaminating the shop. The water will need to be treated as you would any other contaminated material.

The bottom line is this: Lead poisoning happens slowly, and the effects are not obvious until they are very serious. Follow every safety precaution possible to protect yourself.

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## PREPARING NIELLO

No matter which recipe of niello best matches your need, the preparation of it doesn't change. In simple terms, you will alloy the required silver, copper, and lead together, then add it to sulfur. Here is a list of tools and materials I recommend:

- Full-mask respirator
- P100 filter for respirator
- Two crucibles
- Graphite stir rod
- Fume hood
- Sulfur
- Copper
- Silver
- Scale
- Torch
- Steel angle iron
- Mortar and pestle
- Wire mold
- Borax
- Steel spoon
- Ingot mold
- Steel bowl with water

A good fume hood is an absolute requirement for making niello in a shop. The hood must exhaust out of the room, and care must be taken for where the exhaust exits the structure. The fumes from this process will contain large amounts of sulfur as well as some lead. It can also be made outdoors, as long as there is a reasonable breeze to carry away the fumes.

No matter where niello is made, everyone in the studio or area must wear an appropriate full-face respirator. A half-face respirator is inadequate for this work! The respirator must fit properly and be fitted with a P100 cartridge. If you are unsure about the respirator or cartridge you currently have, consult with a

reputable safety equipment supply house. They will be able to provide you with the correct products to protect against lead and sulfur.

Wear clothes you are willing to lose. The smell of burning sulfur is invasive, and you should be willing to discard the clothes you are wearing. Once you begin using niello, and particularly when finishing, your clothes will become contaminated with niello dust. Store and wash these clothes separately from your other laundry to prevent cross-contamination.

The sulfur must be in a powdered form. It is unnecessary to use chemically pure sulfur. I source mine from the garden center where it is sold as a slug deterrent. The sulfur found in the garden center is normally around 92% pure. Despite some historical sources discussing specific quantities of sulfur, it is difficult to give an exact amount. The goal is to saturate the alloy with sulfur. More sulfur is better, and with experience you will get a sense of how much to work with at a time.

The silver should be pure or contain nothing but copper. If it is an alloy such as sterling or coin silver with a known amount of copper in it, take into account the copper content when weighing all the metals. The silver should be cut into small pieces, or in grain form, to assist with rapid melting.

The copper should be pure. Unused copper plumbing tube is a reasonable source. It often contains a very small amount of deoxidizer; however, I have not found it has affected the quality of the niello produced. Do not use pipe taken out of an installation as it may be contaminated with solder. Electrical wire can also be used; however, the preparation by removing the insulation can be tedious. As with the silver, it should be cut into small pieces or in grain form.

Lead is easily found in pure forms. Fishing sinkers are pure lead and a perfect form factor for this application. Do not use weights from car tires. They usually contain other alloys to make them hard enough to survive road conditions. Used bullets are also a poor choice since they are alloyed to make them harder.

Preparation is important before starting. Lay out everything necessary so it is easily at hand. Weigh all metals and keep them separate. I use disposable paper cups to keep everything sorted.

Prepare the two crucibles by coating them in borax and firing them. The crucible used for alloying the metals should be pre-heated before adding any metals. The crucible with the sulfur should not be pre-heated. Fill the sulfur crucible two-thirds full. I prefer whip crucibles as they are convenient and inexpensive. Any crucible used for making niello will be unusable for any other purpose. Clearly label the crucible so it is never used for any other purpose.

The steel angle iron should be a few feet long and be tilted at a slight angle. You will be pouring the molten niello into it and making a long rod of niello. It should be readily accessible and stable while handling the torch and crucible of molten niello. Prepare the angle iron by coating it with a thin layer of cooking oil and burning it off to create a layer of soot. There is no need to heat the angle iron prior to pouring the rod.



Figure 3 Fume hood prepared to make niello

Once everything is laid out and ready (Figure 3), begin by melting the silver with a reducing flame. When the silver is flowing, slowly add the copper. Stir the alloy as necessary to ensure everything has melted and mixed. Once the silver/copper alloy is flowing, slowly add the lead. The temperature will rapidly drop with the addition of the lead. It is important to ensure the lead has melted and alloyed with the existing metal. It has a tendency to sink to the bottom and take on the consistency of butter. Temperature is important from this point on. Too much heat can cause the lead to burn off as well as damage the sulfides you are about to create.

When you are satisfied with the alloy, pour it into the crucible with the sulfur. Stir the mixture and add heat until all the sulfur has been absorbed or burned off. While allowing the sulfur to burn off, there may be a small amount of cinder on the molten niello. You do not want to heat it to the point that the cinder is absorbed into the niello. Instead, remove the cinder with the graphite rod. Once the sulfur has been absorbed or burned off, slowly pour it into the angle iron, forming a long, irregular rod. The rod should be consistent in color throughout and should be brittle. If there is a silver core in the rod, you have overheated the niello or did not add enough sulfur. It is impossible to add too much sulfur, so melt the rod and pour into another crucible of sulfur. Pour into the angle iron again to form a new rod and check it for consistency.

Once you are satisfied with the niello, make it into either rods or powder. If you want to use niello as a powder, melt and pour it into a bowl of water. Remove the niello from the water and grind it in a mortar and pestle. Once ground, it should not be stored for more than a month.

A simple wire mold works well for making niello rods for either immediate or later use. If you do not intend to use the niello immediately, cast it into an ingot mold. It will break down faster if left as a powder for long periods of time.

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#### DESIGNING FOR NIELLO

There are a few considerations required when designing for niello. Any solder work must be completed prior to applying the niello. At soldering temperatures, niello quickly breaks down and the lead will cause pitting in the base metal. The surface where the niello is being applied must remain accessible with files and sanding sticks. If a raised border is required around the niello, it will need to be secured through mechanical means or with a laser welder. In my own work making pens, I use high-temperature Loctite<sup>®</sup> to secure parts together. It holds up well to regular handling and can be released with low enough temperature so as not to affect the niello in the piece.

I have found architectural marble work to be a great source of inspiration for designs. Enamel work also has many of the same design considerations and limitations. Any high-contrast design will work well with niello. The niello will be filed and sanded flat with the surrounding metal. Since niello is a metal and the black color is not a surface treatment like a patina, it can then be engraved to add additional texture and dimension. Niello can also be applied on cylindrical or curved pieces. It is less viscous than enamel and will run from recesses on the opposite side of a cylinder. Care must be taken when applying it to a cylinder. If using a domed object, it must be shaped prior to applying the niello. Niello is brittle at room temperature and may crack if formed after it is fused to the object.

## APPLICATION

There are two principle methods for applying niello. The first method involves using powdered niello and applying it in the same way as vitreous enamel. It can also be formed into thin rods and fed into the cavity while the base object is heated.

Regardless of which method you choose, the base object is created and prepared in the same way. A pocket or depression of some kind is made in the object, and the niello fills it. Preparation of the base object is important. It should be clean and given a light scratch with a wire brush.

When using powdered niello, mix it with a small amount of powdered borax and turn it into a paste by adding water. This method of application is similar to wet-packing enamel. Overfill the depression, and allow the water to evaporate. Gently heat the piece (preferably from the bottom). It is important to heat the base piece instead of the niello directly. It is very easy to overheat the niello by using direct heat on it. Overheating will lead to the niello breaking down and becoming heavily pitted. The wet-packing technique works well when filling large areas.

When using sticks of niello, prepare the piece with a thin paste of borax. Gently heat the base piece, and watch for the borax to turn to a clear, glassy layer. Touch the end of the niello rod to the depression. If the base object is hot enough, it will flow into the area to be filled. Overfill any area to be filled. This technique works well when filling large areas as well as fine lines such as those from engine turning or engraving. When the niello is hot but not flowing, it can be manipulated with a steel spatula. Small voids can be filled by pushing the hot niello around.

If you are working on a material that does not require flux to protect the surface during normal soldering operations, you can omit the borax from both techniques. I primarily work in Argentium<sup>®</sup> silver and do not use any flux while applying niello.

Once applied, file the niello level with the surrounding material. A three-sided hollow scraper can be effective for shaving away excess niello. A second layer of niello is applied after filing to fill in any pockets left after the first layer. Alternating filing/scraping and filling is performed until a solid, level surface is achieved. I find two or three applications are required on flat pieces and three or four on more complex pieces such as cylinders.

Because the niello is fusing to the underlying metal, it is possible to use very shallow depressions. Hand engraving or engine turning work well as channels for niello to fuse into.

#### FINISHING

There are a few challenges involved with finishing niello. The first challenge is contamination. Any tools (files in particular), sandpaper, buffing wheels, etc. need to be dedicated to niello work. Once a tool has been used for niello work, do not use it on a piece not intended for niello. Also, do not use these tools on a piece until you are ready to work the niello. Due to the lead in niello, if a small particle is on your workpiece while soldering, the high temperatures will allow the lead to alloy with the base piece and cause pits.

You must be careful when finishing niello. It is hard enough to file, sand, and polish; however, it is still softer than the surrounding silver or gold.

Begin with files and scraper, and move to a 220-grit sandpaper depending on the cut of your files. Move through 320-, 400-, 600-, 800-, and 1000-grit sandpaper. Be sure to use a sanding stick, and add a piece of thick sole leather if you need a slightly more forgiving surface for a three-dimensional surface. Avoid removing too much niello in any one area as it is easy to damage the pattern by being too aggressive in one area. As the underlying silver becomes visible, switch to less aggressive methods for removing the niello.

Niello is a hard enough metal to allow buffing; however, care must be taken not to use an aggressive compound or work a single spot for too long. It is critical that all scratches are removed with sanding before buffing. The niello will be removed faster than the surrounding silver, so use a light touch. Most of the polishing work should be done with paper. Buffing is just the final touch. There is no need to polish beyond a Tripoli.

Niello is valuable, and the filings can be collected and re-melted. You may have some of the base metal mixed in; however, it should be low enough in volume not to matter. I re-melt my filings with a larger mass of niello to avoid issues.

#### NIELLO RECIPES

There are an infinite number of niello recipes to be found in books and articles ranging from ancient Roman to modern. There are some trends in the recipes over time, but everyone has their own recipe to suit their needs. I chose to experiment with six common recipes found during my research, each of which represents a different approach to the alloy (Table 1). Each recipe was made in a 20-gram batch and applied to an Argentium® 935 disk cast with the same logo. The logo has both thin and thick lines and a small 'island' of silver inside an area of niello (Figure 4). Two applications of niello were completed, along with filing, scraping, and sanding in between. They were finished with a Tripoli buff. They were left with the pits and inconsistencies of having only two applications of niello. If this were client work, one or more additional applications would be used to improve the fill of each piece.

#	Source	Silver	Copper	Lead
1	Pliny	3	2	0
2	Theophilus	4	2	1
3	Cellini	1	2	3
4	Fike	3	1	1
5	"Modern French"	3	7	5
6	Wilson	6	2	1

#### Table 1 Niello recipes



*Figure 4* Six sample niello recipes as applied to Argentium<sup>®</sup> disks (top row, left to right: Recipes 1-3; bottom row, left to right: Recipes 4-6)

## 1. Pliny (3:2:0)

The first recipe stands out from the rest as it is the only one that doesn't contain lead. It is a pre-medieval recipe and would have been used primarily on bronze. The niello produced is a deep, consistent black. The lack of lead changes it in a few ways. First, it requires a very high temperature to apply. The temperature is high enough to cause the sulfides to break down. The example shows significant pitting from that breakdown. I expect deeper pockets would be required to get satisfactory results. This recipe is also very hard and brittle. Scraping was not possible without shattering the niello, and it was substantially harder while filing than the other recipes. Other than its lack of lead, this recipe has no advantage over the others. I would not recommend using it.

## 2. Theophilus (4:2:1)

This is the first of the two medieval recipes tested. It is well documented in Theophilus' treatise, *On Divers Arts.*<sup>4</sup> It increases the proportion of silver as well as adding a small amount of lead, unlike Pliny. The increase in silver content leads to a deep black color. The addition of lead decreases the melting temperature slightly and improves the workability. It fills both large areas and fine details easily. Excess niello can be easily scraped or filed away. My current work relies upon this recipe, and it is recommended.

## 3. Cellini (1:2:3)

The third recipe comes from Benvenuto Cellini's *Treatises on Goldsmithing and Sculpture*, published in the 15th century. Niello work was extremely important to a goldsmith's livelihood in Renaissance Italy, and Cellini discusses its use in the first chapter of his treatise. His recipe opts for a large proportion of lead and small proportion of silver. I suspect this choice was to save precious metal and reduce cost. Application was very challenging. It required significant heat to allow it to flow into all areas of detail and had difficulty filling consistently. The most significant difficulty comes from the silver precipitating out of the solution. It creates areas of silver instead of the dark grey of the rest of the niello, and it obliterates many details. I would not recommend using this recipe.

## 4. Fike (3:1:1)

This recipe comes from Phillip Fike's paper published as part of *Metals Technic.*<sup>6</sup> It was very easy to work with and flowed into all areas of the work without difficulty. Clean-up using a scraper or file was easy. The result is not as black as with Theophilus' recipe, and some gray mottling is visible where the silver has partially come out of solution. The mottling is not as pronounced as with Cellini and is not apparent from arm's length. It is an acceptable recipe.

## 5. "Modern French" (3:7:5)

The "Modern French" recipe comes from H. Wilson's *Silverwork and Jewellery*<sup>7</sup> from the turn of the last century. It contains the largest percentage of copper as well as a large percentage of lead. It produces the best black of any of the six recipes. The black is very consistent and very deep. It was easy to apply, and clean-up was simple. It is closest to Theophilus' recipe in terms of flow and clean-up. I would recommend this recipe and will be experimenting with changing to it or a variation in future work.

#### 6. Wilson (6:2:1)

The final recipe is very similar to Theophilus'; however, it contains a larger percentage of silver. It is Wilson's preferred recipe, but the results are not as consistent as with Theophilus. It fills well and maintains details. The mottling is slightly more pronounced than Fike, and overall it is not as black as Theophilus or "Modern French." The mottling is visible at arm's length if you know what to look for. It is not recommended.

#### CONCLUSION

Niello is underused by modern Western jewelers. With a bit of experimentation, there is great potential when combined with 3D printing, CNC machining, and modern engraving to give new life to this ancient technique.

"Oh thou discreetest of readers, marvel not that I have given so much time in writing about all this, but know I have not even said half of what is needed in this same art, the which in very truth would engage a man's whole energies, and make him practice no other art at all."

Benvenuto Cellini

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