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Abstract

Latent bloodstains are valuable evidence at a crime scene. Leucocrystal Violet (LCV), the reduced form of Gentian Violet, detects bloodstains not easily visible to the naked eye on porous and non-porous surfaces and enhances the contrast of bloodstains for photography by producing a deep violet color upon reacting with the heme group in blood. Often, attempts are made to clean up crime scenes prior to their discovery. Commonly used household cleansers include bleach and bleach-based cleansers, abrasives, and enzymatic cleansers. The purpose of this research was to determine the reactivity of LCV with various common household cleaning products and to determine if LCV still reacted to blood that had been "cleaned up" using the cleansers at various strengths on various substrates. In total, 33 cleansers and five substrates were used. Each cleanser was first tested with LCV to determine if the cleanser produced a false reaction with LCV. A true positive reaction is one that shows a color change with the detection of blood when the substrate is developed with the LCV. If a false positive was found, a time-elapsed test was performed to determine the amount of time that must pass before the false positive was negated; LCV was not applied to a "cleaned" bloodstain until after that time period. For each cleanser evaluated, 0.25 ml of defibrinated sheep's blood was deposited onto and evenly spread in a two-inch circular stenciled pattern on five different substrate materials: linoleum, laminated wood flooring, porcelain tile, painted dry wall, and painted wooden baseboard. The blood was allowed to dry completely. The blood was then cleaned using one of the cleaning products at the specified strength: 100%, 75%, 50%, and 25%. Ultrapure reverse osmosis water was used to dilute the cleansers. Each test was photographed to document results. Quality control tests were done each day using a 1/100th dilution of defibrinated sheep blood. Two cleansers, Great Value All Purpose Cleanser with Bleach and Clorox Bleach, did give a false positive result that dissipated after 30 minutes and 60 minutes, respectively, on all tested substrates. The results of this study showed that for all substrates and strength levels, 5.15% of cleaners showed presumptive negative reaction with the LCV. The results show that for all substrates and strength levels, 18.64% of cleaners had no effect on cleaning the blood off of the substrate. The results also show that the substrate that is best examined when looking for latent bloodstains is wooden baseboard.

Keywords: Leucocrystal Violet, LCV, Latent Bloodstain, Cleanser, Presumptive Positive, Presumptive Negative

The Reaction Between Leucocrystal Violet and Various Household Cleaning Products

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STYLE MANUAL

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Chapter 1

Introduction

In crimes of violence, blood is one of the more valuable pieces of evidence at the crime scene. The presence of blood can determine a multitude of information that can be used to assist in the solving of the crime. DNA from the blood may be analyzed by a forensic biologist to identify both the victim(s) and perpetrator(s). Bloodstains can also be analyzed by a bloodstain pattern analyst to determine where victim(s) and perpetrator(s) were during bloodletting events of the crime. Such information can lay down the framework that ultimately forms the path of the investigation. Previously, this information was obtained through blood typing and preliminary testing such as the benzidine test, but is now determined through other testing procedures.[3]

The analysis of bloodstains uses the methods developed from natural sciences and mathematics for bloodstain pattern analysis. Being able to presumptively determine that any particular stain is blood at the scene is essential, so as not to waste valuable resources doing expensive and time-consuming DNA testing on stains that are not really blood, and this testing must be done by a trained and knowledgeable scientist. The testing of suspicious stains is typically done by a crime scene technician using a rapid screening method. The screening method used in this process must be one that has a high degree of sensitivity and specificity to determine that a given stain is blood. The test should be safe and easily performed without requiring complicated steps to produce a result. Once this has been accomplished, the task of understanding how events occurred that created the bloodstain can be done.[14]

Leucocrystal Violet (LCV) is one of the available rapid screening methods. LCV has been in use since the Federal Bureau of Investigation started using it in their laboratory in 1993. The formula was presented by John Fischer that same year[2]. Hemoglobin is a heme-containing

protein[17], and LCV has an affinity for proteins such as hemoglobin. The reaction is between the hydrogen peroxide within the LCV solution, where the LCV that has attached itself to the heme protein is oxidized to crystal violet forming the violet reaction color.[15] This oxidation will occur slowly under the effect of light and oxygen, but it is not permanent. It is possible to use LCV as a chemical search tool to find latent blood stains at a crime scene, though it is less commonly used for this purpose due to surface staining. Approximately 45 minutes after using LCV on a surface the background will also be colored purple.

In modern crime scene work, LCV is typically used to enhance and stabilize bloody fingerprints or bloody shoe impressions for further evaluation by other forensic scientists. The ability to fix stains in place, in addition to providing contrast on light-colored substrates, is one of the main advantages of using LCV. Other rapid detection methods such as luminol also allow the visualization of bloodstains, but they often dilute the stain and are not ideal when working on vertical surfaces. In addition, LCV allows for visualization of stains for a longer period of time than other chemical enhancement methods. The exposure to light can cause the background surface to become violet due to absorption of light energy of the LCV, whereas methods like luminol are transient (on the order of less than 1 minute), necessitating reapplication of the product or working in teams to adequately document the stain. Previous studies have been done to analyze the sensitivity of four common rapid screening methods, though LCV was not among the chemicals tested.[3] Other studies have been done to determine if various cleaning agents will interfere with the collection and detection of DNA, but the ability to obtain a result with LCV after an item was cleaned was not the purpose of that study.[6] It is known that chemicals such as strong oxidizers, such as sodium hypochlorite, or chemicals that act as catalysts, such as peroxidases or metals, can cause false positive reactions with presumptive tests[1].

Often, attempts are made to clean up a bloody crime scene by the perpetrator to cover up evidence of a crime. Generally speaking, these persons would only have those cleansers available to them that would be available at a grocery or other household products retailer. Specialized cleansers used by professional crime scene clean-up crews are on the market, but many require special licensing to use and are not available to the average person. The purpose of this study is two-fold: to determine if there are commonly available household cleansers that produce false positive or false negative results with LCV, and to determine if there is a minimum concentration of these cleansers needed to completely remove blood so that a subsequent LCV test is negative. Multiple substrates were examined in this study to determine if substrate material had any bearing on results obtained with LCV.

Chapter 2

Materials & Methods

Materials

Defibrinated sheep's blood was obtained from Hemostat Laboratories (Dixon, CA) and was kept refrigerated until 30 minutes prior to use. LCV was obtained from Doje's Forensic Supplies (Ocoee, FL) and mixed as needed according to the manufacturer's instructions. Substrates were purchased from hardware stores in Olathe and Emporia, KS. If needed, substrates were cut into square blocks of an approximate 3-inch by 4-inch size prior to use. A photographic light box was constructed. The drywall and wooden baseboard substrates were painted with 2 coats of Kilz® White Interior Paint (Masterchem Industries LLC, Imperial, MO) and then sectioned. A two-inch circle stencil was created with a piece of solid cardboard using a mathematical compass and Exacto knife. The Quality Assurance (QA) Cards were created using Microsoft® Paint and printed using Microsoft® Word onto cardstock.

False Positive Tests

All cleansers were tested following the general testing procedure (below) in the absence of blood. A series of time elapsed tests were conducted on all five substrates with any cleanser reacting with LCV in the absence of blood. To perform the test, fifteen pieces of each substrate were used. The pieces of substrate were labeled with the name of the cleanser and then in 5 minutes increments starting with 0 minutes. The substrates were then wiped with a paper towel soaked with the respective cleanser and a timer started. The first piece of substrate labeled "0 Minutes" was immediately sprayed with one spray of the LCV. After spraying with the LCV, the piece was allowed to develop for 30s and photographed. Each of the remaining pieces were

sprayed with one spray of the LCV at their respective time interval until there was no visible reaction between the cleanser and the LCV.

Testing Procedures

Experimental Design

All experiments were conducted at Emporia State University in the Forensic Science Laboratory Space in Emporia, Kansas. A full Tyvek® suit, latex gloves, eye protection, and HEPA mask was worn during all testing. The testing was conducted on a single substrate at a specified strength level of the cleansers one at a time to ensure there was no cross contamination in the testing process. For each testing phase there were 33 pieces of substrate that were labeled with the name of the cleanser being used and the strength level being tested using a black colored Sharpie® marker. A two-inch circle was also stenciled onto each piece of substrate using a black colored Sharpie® marker. All dilutions of the cleansers were made by diluting the cleanser with ultrapure reverse osmosis water in a clean vessel. Between each use of the graduated cylinder with each of the cleansers, the cylinder was flushed with 100ml of ultrapure reverse osmosis water to remove any residual mixture from the cylinder before continuing with the next cleanser mixture. Separate individual graduated cylinders were used for each of the petroleum-based cleansers.

A graduated pipette was used to deposit 0.25ml of the defibrinated sheep's blood onto the substrate inside of the stenciled circle. The blood was spread using a gloved finger in a circular pattern across the entire stenciled circle without going outside of the circle. The defibrinated sheep's blood was then allowed to dry to the touch. Once the blood was dry, the cleaning phase began. To clean the substrate, a new, clean, half sheet of Bounty® brand paper towel was folded

into quarters by folding it once across the longitudinal axis and then again across the latitudinal axis. A graduated cylinder was used to measure out 10ml of the cleaning mixture that corresponded with the labeled cleanser on the substrate. The 10ml of cleaning mixture was then deposited onto the folded sheet of paper towel. Approximately 20 wipes from right to left were made with the paper towel to clean each substrate to the point of "no visible blood present." Once each substrate was cleaned, it was allowed to air dry before applying the LCV. The cleaned substrate was then developed using one pump of the hand sprayer on the bottle of LCV. The LCV was allowed to develop for 30s before they were photographed in the photographic light box using a Nikon D7200 digital camera at $f/8$, $1/30^{th}$ second exposure, and ISO 100. Each test was performed once per strength level on each substrate.

Quality Assurance

Before each day of testing, the LCV was tested using a quality assurance (QA) test performed by using a $1/100^{th}$ strength blood/water mixture on a QA card. One drop of the $1/100^{th}$ mixture was deposited onto the cardstock and allowed to soak into the cardstock. The QA Card was then developed using one pump of the hand pump on the bottle of LCV. Reactivity was determined after 30s, as recommended by the manufacturer. If the QA Card showed no reaction in the positive circle, then a new batch of LCV was prepared according to the manufacturer's instructions.

Controls

A test was performed using the LCV using sheep's blood to ensure that the LCV would react with the sheep's blood. A negative control test was performed using LCV and the ultrapure

reverse osmosis water. A test was performed using each of the cleansers without the sheep's blood for the false positive test.

Scoring

The developed pieces of substrate were then scored using a 0 – 4 scale (Table 1) and the results recorded in an Excel spreadsheet. A level 0 score is defined as a presumptive negative LCV reaction (Figure 1, 6, 11, 20). A level 1 score is categorized as a presumptive very weak positive LCV reaction (Figure 2, 7, 12, 16, 21). A level 2 score is categorized as a presumptive weak positive LCV reaction (Figure 3, 8, 13, 17, 22). A level 3 score is categorized as a presumptive strong positive LCV reaction (Figure 4, 9, 14, 18, 23). A level 4 score is categorized as a presumptive very strong positive LCV reaction (Figure 5, 10, 15, 19, 24).

Chapter 3

Results

Cleanser-LCV Interaction

Two of the cleansers produced false positive results - Great Value All Purpose Cleanser with Bleach and Clorox Bleach. For the Great Value All Purpose Cleanser with Bleach there was no reaction with the LCV after 30 minutes of elapsed time on all substrates. For the Clorox Bleach there was no reaction with the LCV after 60 minutes of elapsed time

Detection of Blood After Cleaning

Laminated Wood Flooring

The laminated wood flooring presented no difficulties with the cleaning process. Every piece of flooring was cleaned with each of the cleansers at all strength levels and all cleansers at all strength levels were able to clean the flooring so that there was no visible blood present (Table 2). At the 25% strength level there were no cleansers that were able to remove the blood so that there was no visible reaction with the LCV when developed. At the 50% strength level, only three of the cleansers--Clorox Bleach™, Great Value All Purpose Cleaner with Bleach™, and Natures Miracle Stain and Odor Remover®--were able to remove the blood so that there was presumptive negative reaction with the LCV when developed. At the 75% strength level, there were also three cleansers that were able to remove the blood so that there was a presumptive negative reaction with the LCV. These three cleansers were the Great Value All Purpose Cleaner with Bleach™, Bona Hardwood Floor Cleanser® and the Woolite Advanced Pet Stain and Odor Remover®. At the 100% strength level there was again a presumptive negative reaction with the LCV with the Clorox Bleach™ and CLR®. A standard deviation for all the

cleansers was calculated from their range of scores. Overall, the Clorox Bleach™ presented with the lowest standard deviation with a value of 0.577 from an average score of 0.50 for all tests. The cleanser that exhibited the worst scores was Zout® with an average score of 3.75 for all strength level tests. The cleanser with the most consistent score and a standard deviation of 0.00 was the Oxy-Clean™ with a score of 1 for all strength level tests.

Linoleum Flooring

The linoleum flooring also presented no difficulties with the cleaning process (Table 3). Every piece of flooring was cleaned with each of the cleansers at all strength levels and all cleansers at all strength levels were able to clean the flooring so that there was no visible blood present. At the 25% strength level there was one cleanser that was able to remove the blood to present a presumptive negative reaction when developed with the LCV. That cleanser was the Clorox Bleach™. At the 50% strength level, there were three cleansers that were able to remove the blood to present a presumptive negative reaction with the LCV when developed. Those cleansers were the Clorox Bleach™, the Great Value All Purpose Cleanser with Bleach™, and the Works Toilet Bowl Cleanser®. This is the first presentation of the same cleanser having shown a presumptive negative reaction at the 25% strength level as well as the 50% strength level. At the 75% strength level there were four cleansers that removed the blood off to present with a presumptive negative reaction when developed with the LCV. These are the same cleansers as those that showed a presumptive negative reaction at the 50% strength level with that addition of Woolite Advanced Pet Stain and Odor Remover®. At the 100% strength level there were five cleansers that removed the blood off to present with a presumptive negative reaction when developed with the LCV. These are the same cleansers that showed a presumptive

negative as those at the 75% strength level though now including CLR® in the group. It is notable that each of the cleansers that exhibited a presumptive negative reaction at a lower strength levels continued to present the same presumptive negative reaction with the higher concentration of the cleanser in later tests. Overall, the Clorox Bleach™ presented with the lowest scores as it had a presumptive negative reaction at all strength levels, and therefore a standard deviation of 0.00 from an average score of 0.00 for all tests. The cleanser that exhibited the worst scores was the Palmolive Dish Soap® with an average score of 3.50 for all strength levels.

Painted Drywall

The painted drywall was a porous surface and thus was more difficult to adequately clean (Table 4). At the 25%, 50% and 75% strength levels, The Works Toilet Bowl Cleaner® was not able to clean the drywall to the point of no visible blood. This is with over 30 wipes from right to left whereas the remaining cleansers took approximately 15 wipes from right to left to clean the drywall to the point of no visible blood. In each of the cases with The Works Toilet Bowl Cleaner®, there was always a small amount of "spotting" that remained after cleaning. This spotting occurred due to the presence of blood inside the nooks of the drywall and The Works Toilet Bowl Cleaner® being unable to access the blood there. The Works Toilet Bowl Cleaner® presented with a mean score of 1.50 for all strength levels. While the remaining area of blood placement was relatively clean and is the reason for the low mean score, there was a 1.00 standard deviation across all strength levels due to the cleanser not being able to reach these nooks where blood remained. At the 100% strength level, Goo Gone®, Klean Strip Paint Thinner™, and Orange Glo Wood Furniture 2in1 Cleaner/Polish® did not clean the blood at all.

The full amount of blood remained on the drywall with none removed using any of these cleansers. It is theorized that this is due to the petroleum base for each of these cleansers. As such, their results at the 100% strength level was scored a level 4. As with the laminated wood flooring, no cleansers at the 25% strength level were capable of producing a presumptive negative reaction with the LCV. At the 50% strength level only one cleanser was able to present a presumptive negative reaction when developed with the LCV. That cleanser was the Clorox Bleach™. At the 75% strength level again Clorox Bleach™ was the only cleanser that was able to present with a presumptive negative reaction when developed with the LCV. At the 100% strength level, three cleansers were able to present with a presumptive negative reaction when developed with the LCV. Those cleansers were the Clorox Bleach™, Great Value All Purpose Cleaner with Bleach™, and Woolite Advanced Pet Stain & Odor Remover®. For each of these cleansers that presented with a presumptive negative reaction during the testing, the Clorox Bleach™ performed the best with a mean score of 0.25 and a standard deviation of 0.50 across all strength levels. The cleansers that exhibited the worst scores was a total of four different cleansers with a mean score of 4.00 for all strength level tests. Those cleansers are Great Value Cleaning Vinegar™, Palmolive Dish Soap®, Pine-Sol®, and Zout®.

Painted Wooden Baseboard

The painted wooden baseboard was textured and porous and retained significant amounts of blood during the cleaning process (Table 5). At the 25% strength level The Works Toilet Bowl Cleaner®, Easy Off®, and Great Value All Purpose Cleaner with Bleach™ were unable to clean the drywall to the point of no visible blood. At the 50% strength level there were seven cleansers that were unable to clean the drywall to the point of no visible blood. Those cleansers were Clorox Bleach™, Great Value All Purpose Cleaner with Bleach™, Great Value Cleaning

Vinegar™, Orange Glo 2 in 1 Cleaner/Polish®, Oxy-Clean™, The Works Toilet Bowl Cleaner®, and Easy Off®. At the 75% strength level and 100% strength level there were two cleansers that were unable to clean the drywall to the point of no visible blood. This is due to the blood being inside of the natural nooks that are formed during the manufacture of the baseboard and the inability of the cleansers to clean there. At the 100% strength level there were also three cleansers that had no effect at removing any of the blood. Those cleansers were, Goo Gone®, Klean Strip Paint Thinner™, and Orange Glo 2 in 1 Cleaner/Polish®. Again, it is theorized that this is due to the petroleum base on each of these three products. The last issue is that none of the cleansers at any of the strength levels were capable of showing a presumptive negative result when tested against the baseboard. This resulted in a minimum score of at least 1 for every cleanser at every strength level. The lowest mean score for all cleansers was 1.25 for both Great Value All Purpose Cleanser with Bleach™ and the Woolite Advanced Pet Stain and Odor Remover®. Both of these cleansers also had a standard deviation of 0.50 across all strength levels. The cleansers that exhibited the worst scores were the Pine-Sol® and Zout® with a mean score of 4.00 for all strength level tests.

Porcelain Tile

The porcelain tile presented was smooth and non-porous and cleaned well with most cleansers (Table 6). The 100% strength level the Goo Gone®, Klean Strip Paint Thinner™, and Orange Glo 2 in 1 Cleaner/Polish® were unable to completely clean the tile of the blood. This is due to the petroleum base in each of these cleansers. At the 25% strength level, one cleanser was able to produce a presumptive negative reaction with the LCV. That cleanser was the Clorox Bleach™. At the 50% strength level the Clorox Bleach™ was also able to produce a

presumptive negative reaction with the LCV. At the 75% strength level four cleansers--Clorox Bleach™, the Great Value All Purpose Cleaner with Bleach™, Pine-Sol®, and Woolite Advanced Pet Stain and Odor Remover®--that were able to produce a presumptive negative reaction with the LCV. At the 100% strength level there were three cleansers that were able to produce a presumptive negative reaction with the LCV. Those cleansers were the Clorox Bleach™, the Great Value All Purpose Cleaner with Bleach™, and Woolite Advanced Pet Stain and Odor Remover®. It is notable that all of the cleansers, except for the Pine-Sol®, that exhibited a presumptive negative reaction at lower strength levels continued to present a presumptive negative reaction with the higher concentration of the cleanser. Among those cleansers that exhibited a presumptive negative reaction during the testing, the Clorox Bleach™ presented with the lowest standard deviation as it showed a presumptive negative reaction at all strength levels and therefore a standard deviation of 0.00 from an average score of 0.00 for all tests. The cleanser that exhibited the worst scores was Zout® with an average score of 3.75 for all strength level tests. For the porcelain tile there were two cleansers that resulted in a high standard deviation of 1.50 across all tests. Those two were the CLR® and the Klean Strip Paint Thinner™ with a mean score of 2.25 and 2.75 respectively.

Chapter 4

Discussion

The first aim of the study was to determine if there are any commonly available household cleansers that produce a false positive result when used in conjunction with LCV. It was found that two of the commonly available cleansers tested that do result in a false positive result--Clorox Bleach™ and the Great Value All Purpose Cleaner with Bleach™. These two cleansers were tested on each substrate without the addition of blood. After a period of 30 minutes or longer the false positive with the Great Value All Purpose Cleaner with Bleach™ was negated. After a period of 60 minutes or longer the false positive with the Clorox Bleach™ was negated. No other cleansers produced this false positive result. It is thought that the false positive result with these two cleansers is the result of the sodium hypochlorite that is a part of the cleanser formulation. It is also believed that the Clorox Bleach™ resulted in the requirement of a longer elapsed time period due to the amount of sodium hypochlorite in the cleanser, as it has 5-7% sodium hypochlorite, whereas the Great Value All Purpose Cleaner with Bleach™ has 1-3% in its makeup. Other studies have shown that the use of a cleanser containing sodium hypochlorite will require a minimum of 8 hours after cleaning to negate the false positive when Luminol is used.[4, 5] Based on the results of this research, LCV may be a better choice, as the maximum time required between cleaning with solutions containing sodium hypochlorite and application of the LCV was 60 minutes.

The second goal of the study was to determine if any commonly available household cleansers were able to produce a presumptive negative result with an LCV test. The results from the research show that several cleansers are able to produce this presumptive negative; however, the results also show that this is substrate dependent. The best results were obtained when using

Clorox Bleach™ across all strength levels and substrates. Clorox Bleach™ resulted in a mean score of 0.45 and a standard deviation of 0.62 across all strengths and substrates.

The cleansers that were able to produce a presumptive negative result were able to do so consistently throughout the testing with each successive higher strength level. There were cleansers that were able to successfully produce a presumptive negative result at a lower strength level but at a higher strength level showed a presumptive positive result, although these results were only obtained when tested using the laminated wood flooring substrate. It is believed that this is due to the surface construction of the laminated wood flooring which presents with surface irregularities to mimic a wooden texture. As the cleansers are mixed with water the viscosity of the overall solution drops which allowed greater penetration into these surface irregularities. This is believed to be the reason why the laminated wood flooring results were better for some of the cleansers at a lower strength level than at a higher strength level. The porcelain tile did have one outlier with the Pine-Sol®.

A presumptive test is one in which a specific analysis is done on a sample and, based on that analysis, either identifies the sample as definitely not a particular substance/material or, alternatively, establishes that the sample probably is that particular substance/material. When the substance being tested is thought to be blood, LCV testing can establish that it is definitely not blood or that it probably is blood. As with any presumptive test, however, it is then necessary to perform a confirmatory test to establish the fact that it is blood. Generally, confirmatory testing is significantly more expensive and time consuming than presumptive testing. Because of that, it is often advantageous in terms of time and cost to perform presumptive testing prior to engaging in confirmatory testing.

LCV testing is a presumptive type test. Because LCV will react with blood, causing a notable color change, a negative reaction will establish that the test material is not blood. However, a positive reaction establishes that the material may be blood. The problem is that there are other materials that can cause the LCV color change that are not blood. Hence, if the test is positive, it is necessary to perform a second, more specific test to ensure that it is blood.

The results of this study are subject to the presumptive nature of LCV. Any presumptive positive result must be verified by a forensic biologist before final determination can be made as to whether the test is conclusive. The research was completed using known samples of defibrinated sheep blood; however, the determination that the blood was removed by the cleansers or if the blood was diluted by the cleansers to the point that a presumptive negative was produced by the LCV when tested remains to be determined.

The scale used to score the results is subjective as in the forensic science community it is common practice to state that results are one of three ranges, presumptive negative, presumptive mild positive, and presumptive strong positive. As the scale used to score the results in this research has one negative and 4 positive results with the middle two scores of either a 2 or 3 being somewhat ambiguous, it may be possible to either change these scores to the presumptive strong positive category or combine these two scores for a result that is presumptively positive but does not fall directly into the strict presumptive mild positive or strong positive in future testing of this kind.

Substrate surface was a key factor in whether blood could still be detected after cleaning. The results of this study indicate that non-porous surfaces will still retain latent blood even after being cleaned by the majority of the cleansers used in the study. The porous surfaces tested,

painted drywall and painted wooden baseboard, were not as cleansable as the non-porous or coated substrates. None of the cleansers were able to completely remove blood from painted wooden baseboard. It is thought that this is due to the porous nature of the wood and the rough texture of the baseboard. Laminated wood flooring did not perform in the same way, most likely due to the polymer coating on the laminated wood flooring. Drywall is also an uneven, somewhat porous substrate, but was more successfully cleaned in this study, likely due to its construction. Drywall construction consists of a barrier on the surface of the gypsum. Adding two layers of paint as was done in this study provided a second barrier to the gypsum which improved or added to the ability of the cleansers to produce a presumptive negative result. While two layers of paint were also applied to the baseboards, clearly the presence of a barrier material affected the results. Non-porous surfaces, such as linoleum flooring and porcelain tile were much more successful at producing the presumptive negative. Surface texture still played a role, because despite both substrates being non-absorptive, porcelain tile, with its smooth texture and glaze coating, was more successful.

The limitations with other chemical enhancement techniques also suggest that in specific cases, LCV may be a better choice. There is no requirement of alternate light sources or the requirement of a dark room in order to observe the reaction results. One limitation to the use of LCV is on dark surfaces where the LCV reaction is not easily visible[16]. If LCV is not being used to enhance and document a stain *in situ*, then part of the suspected stain could be transferred to a lighter colored substrate and LCV applied to work around this limitation. Another drawback to LCV is that it stains everything including non-blood areas a deep violet color after a period of time, so care should be used by the personnel applying it. One concern that crime scene personnel may have in using LCV is potential carcinogenicity. The parent compound, gentian

violet, has been deemed by the Food and Drug Administration to be carcinogenic. However, modern formulations of LCV are considered to be non-carcinogenic and merely requires the use of standard personal protective equipment to be applied safely.

The importance of having more than one chemical enhancement tool for latent bloodstains available[11] for use is important, as previous studies have shown that specific chemical enhancement tools are rendered unusable if the blood is cleaned or laundered with cleansers or detergents that contain active oxygen.[12,13] It also becomes important due to studies that have shown that, in the presence of certain surfactants, the chemiluminescence and electrochemiluminescence that some chemical enhancement tools rely on can be increased or decreased. Two of the cleansers used in this study (Table 8, 9) contain the surfactant used in these studies and 18 of the 33 cleansers used in this study contain one or more surfactants (Table 8, 9, 10).[7, 10] Another study shows that increasing the amount of hydrogen peroxide will increase the chemiluminescent effect with the chemical enhancement tool luminol.[8] Three of the cleansers used in this study contain hydrogen peroxide in their chemical makeup (Table 8, 9). 12 of the 33 cleansers used in this study also contain a form of amine in their chemical makeup (Table 7, 8, 9, 10). Generally speaking, amines can result in a higher pH of the chemical they are associated with. There have been studies done on the effects of amines on chemical enhancement tools and it has been found that a higher pH gives brighter chemiluminescent results which could be misconstrued as a positive reaction, which could in fact be a false positive.[9] The false positive testing done in the beginning of this study shows that the performance of LCV is not affected by these chemicals, making it a more suitable chemical enhancement tool, if it is suspected that latent bloodstains have been cleaned prior to the arrival of crime scene technicians.

Chapter 5

Conclusions

The use of any one chemical enhancement tool over any other is a question of resources of the agency and the preferences of forensic scientists that are using these tools. While no single enhancement technique is likely to work with every substrate, the results of this study indicate that if adequate time elapses before application of LCV, it is less likely to be affected by chemicals in the cleansers than other detection/enhancement methods. The results of this study also indicate that, no matter what type of detection/enhancement agent used, looking for latent bloodstains on or near porous or rough surfaces is more likely to successfully detect traces of blood than non-porous substrates.

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Table 1

Scoring Parameters for Leucocrystal Violet Reactions

Level	Parameters
0	A presumptive negative LCV reaction.
1	A very weak presumptive positive LCV reaction
2	A weak presumptive positive LCV reaction
3	A strong presumptive positive LCV reaction
4	A very strong presumptive positive LCV reaction

Table 2

Laminated Wood Flooring Scores

	25%	50%	75%	100%
409 Multi Surface Cleaner®	3	1	4	2
Bona Hardwood Floor Cleaner®	2	1	0	1
Clean Shower Daily Shower Cleaner™	3	1	2	1
Clorox Bleach™	1	0	1	0
CLR®	3	1	1	0
Easy Off Fume Free Oven Cleaner®	4	2	3	1
Fabuloso®	4	2	1	1
Goo Gone Goo and Adhesive Remover®	2	1	1	1
Great Value All Purpose Cleaner Lemon Scent™	4	2	2	2
Great Value All Purpose Cleaner with Bleach™	3	0	0	1
Great Value Cleaning Vinegar™	2	3	3	3
Great Value Glass Cleaner™	1	1	1	2
Kaboom Foamtastic™	3	2	1	2
Klean Strip Paint Thinner™	3	1	1	2
Lysol All Purpose Cleaner®	4	1	1	1
Mean Green Super Strength Cleaner & Degreaser®	2	3	2	2
Mr. Clean Antibacterial®	4	3	2	2
Natures Miracle Stain & Odor Remover®	2	0	3	2
Orange Glo Wood Furniture 2in1 Cleaner/Polish®	2	2	4	1
Out! Petcare Stain & Odor Remover®	3	1	2	1
Oxy-Clean™	1	1	1	1
Palmolive Dish Soap®	4	4	3	1
Pine-Sol®	4	4	3	3
Pledge Multi Surface Cleaner®	2	1	1	1
Scrub Free Total Bathroom™	2	3	2	3
Scrubbing Bubbles™	4	3	1	2
Seventh Generation Multi Surface Cleaner™	3	3	2	2
Simple Green®	2	2	1	1
Sprayway Glass Cleaner®	2	2	1	1
The Works Toilet Bowl Cleaner®	2	1	1	1
Windex Original®	4	1	2	1
Woolite Advanced Pet Stain & Odor Remover®	1	2	0	1
Zout®	4	4	4	3

Table 3

Linoleum Scores

	25%	50%	75%	100%
409 Multi Surface Cleaner®	4	3	2	1
Bona Hardwood Floor Cleaner®	3	2	2	1
Clean Shower Daily Shower Cleaner™	2	1	1	1
Clorox Bleach™	0	0	0	0
CLR®	2	1	1	0
Easy Off Fume Free Oven Cleaner®	4	3	3	3
Fabuloso®	3	3	2	3
Goo Gone Goo and Adhesive Remover®	2	2	1	1
Great Value All Purpose Cleaner Lemon Scent™	2	2	3	2
Great Value All Purpose Cleaner with Bleach™	1	0	0	0
Great Value Cleaning Vinegar™	2	2	3	3
Great Value Glass Cleaner™	3	3	2	3
Kaboom Foamtastic™	4	3	2	3
Klean Strip Paint Thinner™	2	2	3	1
Lysol All Purpose Cleaner®	2	2	2	2
Mean Green Super Strength Cleaner & Degreaser®	2	2	3	1
Mr. Clean Antibacterial®	2	2	2	2
Natures Miracle Stain & Odor Remover®	2	2	2	2
Orange Glo Wood Furniture 2in1 Cleaner/Polish®	3	3	2	1
Out! Petcare Stain & Odor Remover®	3	2	3	2
Oxy-Clean™	3	2	1	2
Palmolive Dish Soap®	3	4	4	3
Pine-Sol®	2	2	2	2
Pledge Multi Surface Cleaner®	3	3	3	2
Scrub Free Total Bathroom™	3	1	2	1
Scrubbing Bubbles™	3	1	2	1
Seventh Generation Multi Surface Cleaner™	3	3	3	2
Simple Green®	3	3	4	1
Sprayway Glass Cleaner®	2	3	1	2
The Works Toilet Bowl Cleaner®	1	0	0	0
Windex Original®	2	1	1	2
Woolite Advanced Pet Stain & Odor Remover®	2	1	0	0
Zout®	2	4	4	3

Table 4

Painted Drywall Scores

	25%	50%	75%	100%
409 Multi Surface Cleaner®	3	4	4	2
Bona Hardwood Floor Cleaner®	3	4	2	2
Clean Shower Daily Shower Cleaner™	3	4	3	2
Clorox Bleach™	1	0	0	0
CLR®	3	4	4	2
Easy Off Fume Free Oven Cleaner®	3	2	2	3
Fabuloso®	4	3	4	2
Goo Gone Goo and Adhesive Remover®	3	2	2	4
Great Value All Purpose Cleaner Lemon Scent™	4	4	3	3
Great Value All Purpose Cleaner with Bleach™	3	1	1	0
Great Value Cleaning Vinegar™	4	4	4	4
Great Value Glass Cleaner™	3	2	2	2
Kaboom Foamtastic™	3	3	3	4
Klean Strip Paint Thinner™	4	4	2	4
Lysol All Purpose Cleaner®	3	4	2	2
Mean Green Super Strength Cleaner & Degreaser®	3	2	3	2
Mr. Clean Antibacterial®	4	2	3	2
Natures Miracle Stain & Odor Remover®	3	2	3	3
Orange Glo Wood Furniture 2in1 Cleaner/Polish®	4	4	2	4
Out! Petcare Stain & Odor Remover®	3	3	3	2
Oxy-Clean™	4	3	2	2
Palmolive Dish Soap®	4	4	4	4
Pine-Sol®	4	4	4	4
Pledge Multi Surface Cleaner®	4	3	2	2
Scrub Free Total Bathroom™	3	2	3	3
Scrubbing Bubbles™	4	3	4	3
Seventh Generation Multi Surface Cleaner™	4	4	3	3
Simple Green®	3	2	2	3
Sprayway Glass Cleaner®	3	3	1	2
The Works Toilet Bowl Cleaner®	3	1	1	1
Windex Original®	3	3	2	2
Woolite Advanced Pet Stain & Odor Remover®	3	2	1	0
Zout®	4	4	4	4

Table 5

Painted Wooden Baseboard Scores

	25%	50%	75%	100%
409 Multi Surface Cleaner®	3	4	3	3
Bona Hardwood Floor Cleaner®	3	3	2	2
Clean Shower Daily Shower Cleaner™	3	4	3	3
Clorox Bleach™	2	2	1	1
CLR®	4	4	4	2
Easy Off Fume Free Oven Cleaner®	4	3	3	4
Fabuloso®	3	4	3	3
Goo Gone Goo and Adhesive Remover®	3	4	4	4
Great Value All Purpose Cleaner Lemon Scent™	4	4	3	4
Great Value All Purpose Cleaner with Bleach™	4	1	1	1
Great Value Cleaning Vinegar™	4	4	3	3
Great Value Glass Cleaner™	3	3	2	2
Kaboom Foamtastic™	3	3	3	4
Klean Strip Paint Thinner™	4	4	2	4
Lysol All Purpose Cleaner®	3	3	2	3
Mean Green Super Strength Cleaner & Degreaser®	3	4	2	2
Mr. Clean Antibacterial®	4	4	2	3
Natures Miracle Stain & Odor Remover®	3	4	1	3
Orange Glo Wood Furniture 2in1 Cleaner/Polish®	3	4	3	4
Out! Petcare Stain & Odor Remover®	3	3	3	3
Oxy-Clean™	3	4	2	4
Palmolive Dish Soap®	4	4	3	3
Pine-Sol®	4	4	4	4
Pledge Multi Surface Cleaner®	3	4	1	3
Scrub Free Total Bathroom™	3	2	2	2
Scrubbing Bubbles™	3	3	4	3
Seventh Generation Multi Surface Cleaner™	4	4	4	3
Simple Green®	3	3	2	2
Sprayway Glass Cleaner®	3	3	2	3
The Works Toilet Bowl Cleaner®	3	2	1	1
Windex Original®	3	3	2	2
Woolite Advanced Pet Stain & Odor Remover®	2	1	1	1
Zout®	4	4	4	4

Table 6

Porcelain Tile Scores

	25%	50%	75%	100%
409 Multi Surface Cleaner®	4	3	2	2
Bona Hardwood Floor Cleaner®	2	2	1	2
Clean Shower Daily Shower Cleaner™	2	2	1	2
Clorox Bleach™	0	1	0	0
CLR®	4	3	1	1
Easy Off Fume Free Oven Cleaner®	3	3	2	1
Fabuloso®	2	3	1	3
Goo Gone Goo and Adhesive Remover®	3	3	1	4
Great Value All Purpose Cleaner Lemon Scent™	3	2	2	2
Great Value All Purpose Cleaner with Bleach™	1	1	0	0
Great Value Cleaning Vinegar™	2	4	3	2
Great Value Glass Cleaner™	4	3	1	2
Kaboom Foamtastic™	3	3	3	1
Klean Strip Paint Thinner™	4	2	1	4
Lysol All Purpose Cleaner®	3	2	2	2
Mean Green Super Strength Cleaner & Degreaser®	3	3	2	2
Mr. Clean Antibacterial®	3	3	1	2
Natures Miracle Stain & Odor Remover®	2	3	2	3
Orange Glo Wood Furniture 2in1 Cleaner/Polish®	2	3	2	4
Out! Petcare Stain & Odor Remover®	4	3	1	2
Oxy-Clean™	2	2	1	2
Palmolive Dish Soap®	3	3	1	1
Pine-Sol®	2	3	0	1
Pledge Multi Surface Cleaner®	4	2	3	2
Scrub Free Total Bathroom™	3	3	3	2
Scrubbing Bubbles™	2	3	2	2
Seventh Generation Multi Surface Cleaner™	3	3	2	2
Simple Green®	1	2	2	2
Sprayway Glass Cleaner®	3	3	1	2
The Works Toilet Bowl Cleaner®	2	1	1	1
Windex Original®	2	1	1	2
Woolite Advanced Pet Stain & Odor Remover®	2	1	0	0
Zout®	4	4	3	4

Table 7

Overall Cleaning Score 1 or Less

Overall Cleaning Score 1 or less:		Score	Overall Variation	Ingredients	Notes	Classifications						
						Lower pH	Higher pH	Oxidizer	Surfact	Solvents	Amines	Alcohols
	Clorox Bleach	0.50	0.590	sodium hypochlorite (5-7%), sodium chloride (salt), Sodium carbonate (washing soda), Sodium hydroxide (lye), Sodium polyacrylate (dispersant).	Bleach, high pH		X					
	Great Value All Purpose Cleaner with Bleach	0.95	0.600	Sodium Hypochlorite (1-3%), Sodium Hydroxide (pH adjuster), Lauramine Oxide (Surfactant)	High pH, surfactant		X				X	

Table 8

Overall Cleaning Score 1 to 2

Overall Cleaning Score 1 to 2:		Score	Overall Variation	Ingredients	Notes	Classifications						
						Lower pH	Higher pH	Oxidizer	Surfact	Solvents	Amines	Alcohols
	Woolite Advanced Pet Stain & Odor Remover	1.05	0.330	Hydrogen Peroxide (0.5-1%), Also contains surfactants, buffering agent, fragrance, and water. Exact percentages of composition has been withheld as a trade secret	peroxide and surfactants			X	X			
	The Works Toilet Bowl Cleaner	1.20	0.570	hydrogen chloride (2 ppm), Hydrogen Chloride 9.5%,	acidic cleanser	X						
	Windex Original	2.00	0.500	2-Hexoxyethanol (surfactant), Isopropanolamine (cleaning agent), Ammonium Hydroxide (pH adjustment, cleanser), Lauryl Dimethyl Amine Oxide (surfactant), Sodium Dodecylbenzene Sulfonate (surfactant)	High surfactant load; NH3OH		X		X			
	Bona Hardwood Floor Cleaner	2.00	0.680	Hydrogen Peroxide (1-2%), Butoxypropanol, Decyl Glucoside, Colloidal Silica, Citric Acid.	H2O2; Alcohols, citric acid	X		X				X

Table 9

Overall Cleaning Score 2 to 3

Overall Cleaning Score 2 to 3:		Score	Overall Variation	Ingredients	Notes	Classifications						
						Lower pH	Higher pH	Oxidizer	Surfact	Solvents	Amines	Alcohols
	Sprayway Glass Cleaner	2.15	0.450	Ethanol (<5%), Ethanol, 2-butoxy (<5%), propane (<5%), butane (<5%), 2-methyl-2-propanol (<0.1%), Acetic acid, phenylmethyl ester (<0.1%), 1,2-Benzenedicarboxylic acid, 1,2-diethyl ester (<0.1%), 1,1'-oxybis-Benzene (<0.1%), 1-phenyl-Ethanone (<0.1%), Stoddard solvent (<0.1%)	Alcohols, Low MW organics							
	Oxy-Clean	2.15	0.880	Sodium Percarbonate (2Na2CO3.3H2O2 or C2H6Na4O12, 50-60%), Soda Ash/Sodium Carbonate (raises pH to 10-11), Hydrogen Peroxide (product of sod perc), Surfactants/Detergents	High peroxide release		X	X	X			x

Table 9 (Continued)

Overall Cleaning Score 2 to 3

Overall Cleaning Score 2 to 3:		Score	Overall Variation	Ingredients	Notes	Classifications						
						Lower pH	Higher pH	Oxidizer	Surfact	Solvents	Amines	Alcohols
	Simple Green	2.20	0.540	C9-11 Alcohols Ethoxylated (<5%), Sodium Citrate (<5%), Sodium Carbonate (<1%), Tetrasodium Glutamate Diacetate (<1%), Citric Acid (<1%), Methylchloroisothiazolinone (< 0.002%), Methylisothiazolinone (< 0.002%)	Alcohols, some surfactants, citric acid	X			X			X
	Clean Shower Daily Shower Cleaner	2.20	0.870	Caprylyl/capryl glucoside (surfactant), Lauryl glucoside (surfactant), Propylene glycol (processn aid), Ethanolamine (pH adjuster), Alkyl C12-16 dimethylbenzyl ammonium chloride (surfactant), Dicapryl/dicaprylyl dimonium chloride (surfactant), Ethanol (solvent)	High surfactant load, some alcohols		X		X	X		X

Table 9 (Continued)

Overall Cleaning Score 2 to 3

Overall Cleaning Score 2 to 3:		Score	Overall Variation	Ingredients	Notes	Classifications						
						Lower pH	Higher pH	Oxidizer	Surfact	Solvents	Amines	Alcohols
	Great Value Glass Cleaner	2.25	0.590	Ammonium Hydroxide, 2-Butoxyethanol, Propylene Glycol Methyl Ether, D-Glucopyranose, Oligomeric, C6-12-Alkyl Glycosides, Sodium Hydroxide	Ammonium hydroxide, alcohols, low level sodium hydroxide		X		X			X
	CLR	2.25	1.130	Lactic acid (12-18%), gluconic acid (2.5-3.75%), Lauramine Oxide (1.5-3.25%)	Lactic, gluconic acids	X			X			
	Lysol All Purpose Cleaner	2.30	0.450	Quaternary ammonium compounds, benzyl-C12-16-alkyldimethyl, chlorides (<0.1%), Dodecyldimethylamine oxide (0.1-1.0%)	surfactants				X			
	Natures Miracle Stain & Odor Remover	2.35	0.450	Chlorine Dioxide, Alkyl Dimethyl Benzyl Ammonium Chloride, Alkyl Dimethyl Ethylbenzyl Ammonium Chloride,	Oxidizer, surfactants			X	X			
	Mean Green Super Strength Cleaner/Degreaser	2.40	0.290	2-butoxy ethanol (2-7%), trisodium EDTA (1-5%), unknown detergents	alcohols				X		X	X

Table 9 (Continued)

Overall Cleaning Score 2 to 3

Overall Cleaning Score 2 to 3:		Score	Overall Variation	Ingredients	Notes	Classifications						
						Lower pH	Higher pH	Oxidizer	Surfact	Solvents	Amines	Alcohols
	Scrub Free Total Bathroom	2.40	0.420	2-(2-butoxyethoxy)ethanol (1-5%), 2-methylpentane-2,4-diol (1-5%), Alkyl (C14 50%; C12 40%; C16 10%) dimethyl benzyl ammonium chloride (1-5%), N,N-dimethyldodecylamine N-oxide (1-5%), Octyl decyl dimethyl ammonium chloride (1-5%)	Alcohols, some abrasives				X			X
	Goo Gone	2.40	1.020	Petroleum distillates, hydrotreated light (60-100%), D-Limonene (1-5%),	solvents					X		
	Pledge Multi Surface Cleaner	2.45	0.670	Ethyl alcohol (0.1-1.0%),	alcohol							X
	Out! Petcare Stain & Odor Remover	2.50	0.500	Proprietary	Proprietary							
	Mr. Clean Antibacterial	2.60	0.490	Sodium hydroxide, Alcohol ethoxylates	sodium hydroxide, alcohol		X					x

Table 9 (Continued)

Overall Cleaning Score 2 to 3

Overall Cleaning Score 2 to 3:		Score	Overall Variation	Ingredients	Notes	Classifications						
						Lower pH	Higher pH	Oxidizer	Surfact	Solvents	Amines	Alcohols
	Scrubbing Bubbles	2.65	0.720	Isobutane (5-10%), Diethylene glycol monobutyl ether (5-10%), Tetrasodium ethylene diamine tetraacetate (1-5%), Alkyl dimethyl benzyl ammonium chloride (0.0001-0.10%), Decyldimethyloctylammonium chloride (0.0001-0.10%), Dimethyldioctylammonium chloride (0.0001-0.10%), Didecyldimethylammonium chloride (0.0001-0.10%)	solvents and solvating chemicals, abrasives				x	x		
	Fabuloso	2.70	0.570	sodium dodecyl benzene sulfonate (1-5%), C9–11 pareth-8, sodium laureth sulfate, baking soda, pine oil extract and bleach alternative	surfactants, mild alkaline cleaner		X	X	X	X		
	Klean Strip Paint Thinner	2.70	0.820	Stoddard solvent, Trimethyl-Benzene	solvents					X		

Table 9 (Continued)

Overall Cleaning Score 2 to 3

Overall Cleaning Score 2 to 3:		Score	Overall Variation	Ingredients	Notes	Classifications						
						Lower pH	Higher pH	Oxidizer	Surfact	Solvents	Amines	Alcohols
	Easy Off Oven Cleaner	2.80	0.540	2-(2-butoxyethoxy)-Ethanol (2.5-10%), Petroleum gases, liquefied, sweetened (2.5-10%), Sodium hydroxide (2.5-10%), 2-amino-Ethanol (2.5-10%)	solvents, high pH cleanser, some alcohol		X			X	X	X
	Kaboom	2.80	0.540	Urea monohydrochloride (5-10%)	amine cleanser	X						
	409 Multi Surface Cleaner	2.85	0.380	Lauramine oxide (0.5-1.5%), n-Alkyl (40% C12, 50% C14, 10% C16) dimethyl benzyl ammonium chloride (0.2-0.4%)	mild abrasives, possibly solvents				X			
	Orange Glo Wood Furniture 2in1 Cleaner/Polish	2.85	0.630	Petroleum distillates, hydrotreated light (60-100%), White mineral oil, petroleum (10-30%)	solvents					X		
	Great Value All Purpose Cleaner	2.85	0.720	Octyl decyl dimethyl ammonium chloride, Dioctyl dimethyl ammonium chloride, Didecyl dimethyl ammonium chloride, Alkyl Dimethyl benzyl ammonium chloride	mild cleansers with some solvation possible				X			

Table 10

Overall Cleaning Score 3 to 4

Overall Cleaning Score 3 to 4:		Score	Overall Variation	Ingredients	Notes	Classifications						
						Lower pH	Higher pH	Oxidizer	Surfact	Solvents	Amines	Alcohols
	Zout	3.75	0.310	Variety of alcohols, boric acid	alcohols, mildly acidic	X						X
	Seventh Generation Multi Surface Cleaner	3.00	0.590	Polyglucose (1-10%), Coceth-7 (1-10%), Citric Acid (0.3-3%), Sodium Hydroxide (0.1-1%), Sodium Lauriminodipropionate (0.03-3%), Sodium Carbonate (0.03-3%)	solvation, mild abrasion		X		X			
	Palmolive Dish Soap	3.20	0.760	Lauramidopropyldimethylamine Oxide (1-5%), Sodium Chloride (1-5%)	surfactant				X			
	Pine-Sol	3.00	1.170	Alkyl alcohol alkoxylate, Glycolic acid	mildly acidic surfactant	X			X			
	Great Value Cleaning Vinegar	3.10	0.630	acetic acid	mildly acidic	X						

Figure 1

Laminated Wood Flooring Level 0 Reaction

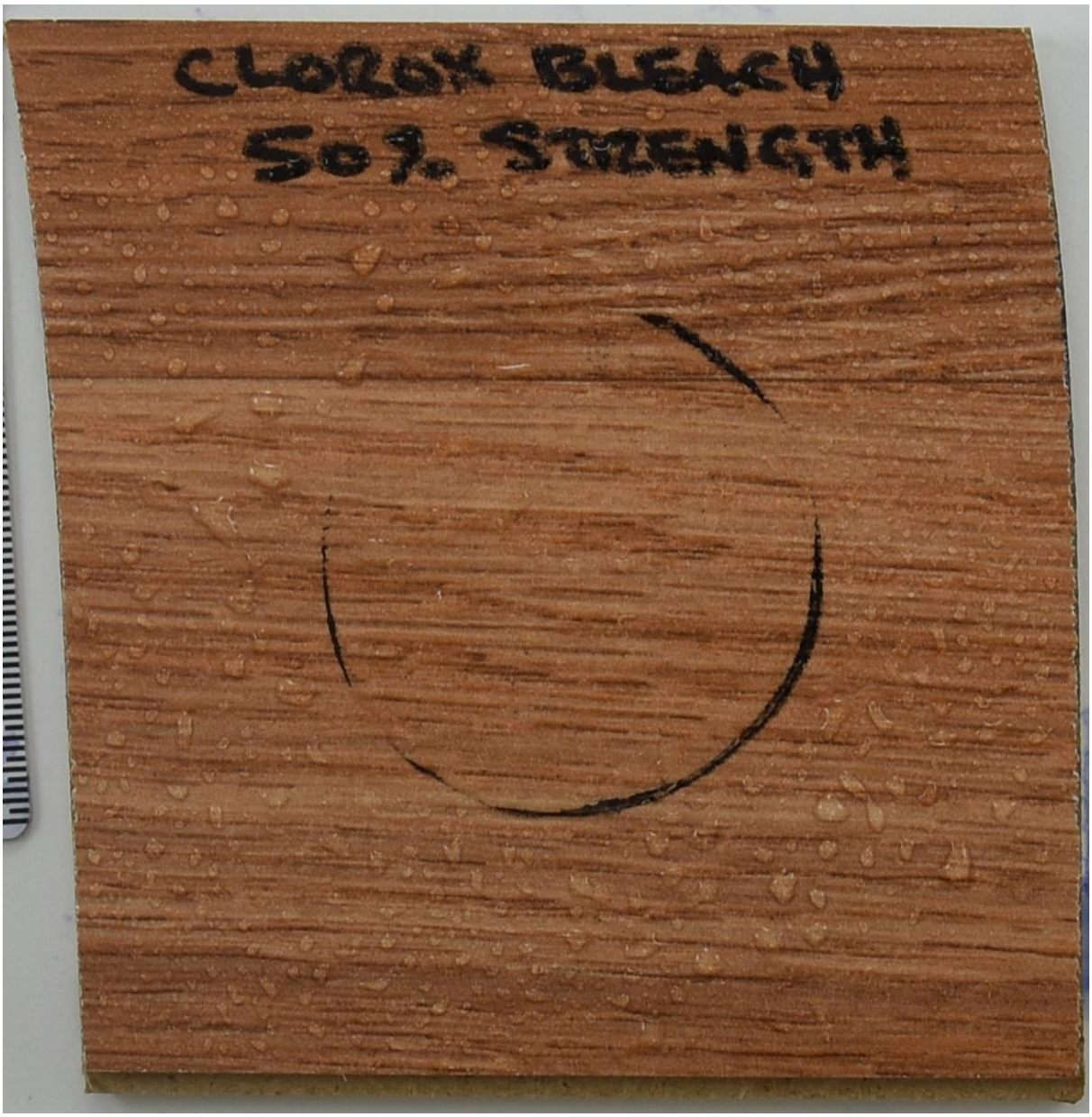

Figure 2

Laminated Wood Flooring Level 1 Reaction

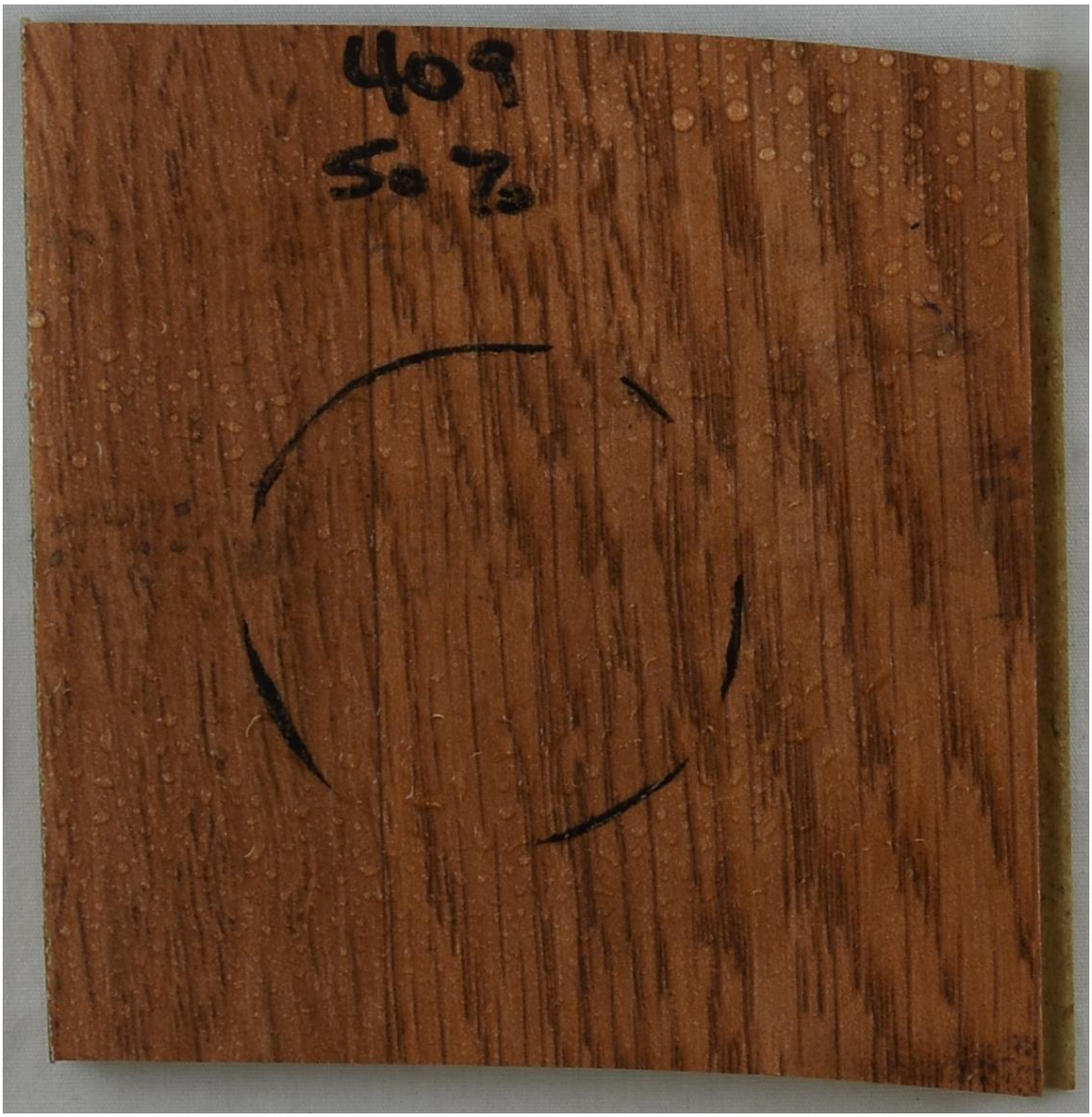

Figure 3

Laminated Wood Flooring Level 2 Reaction

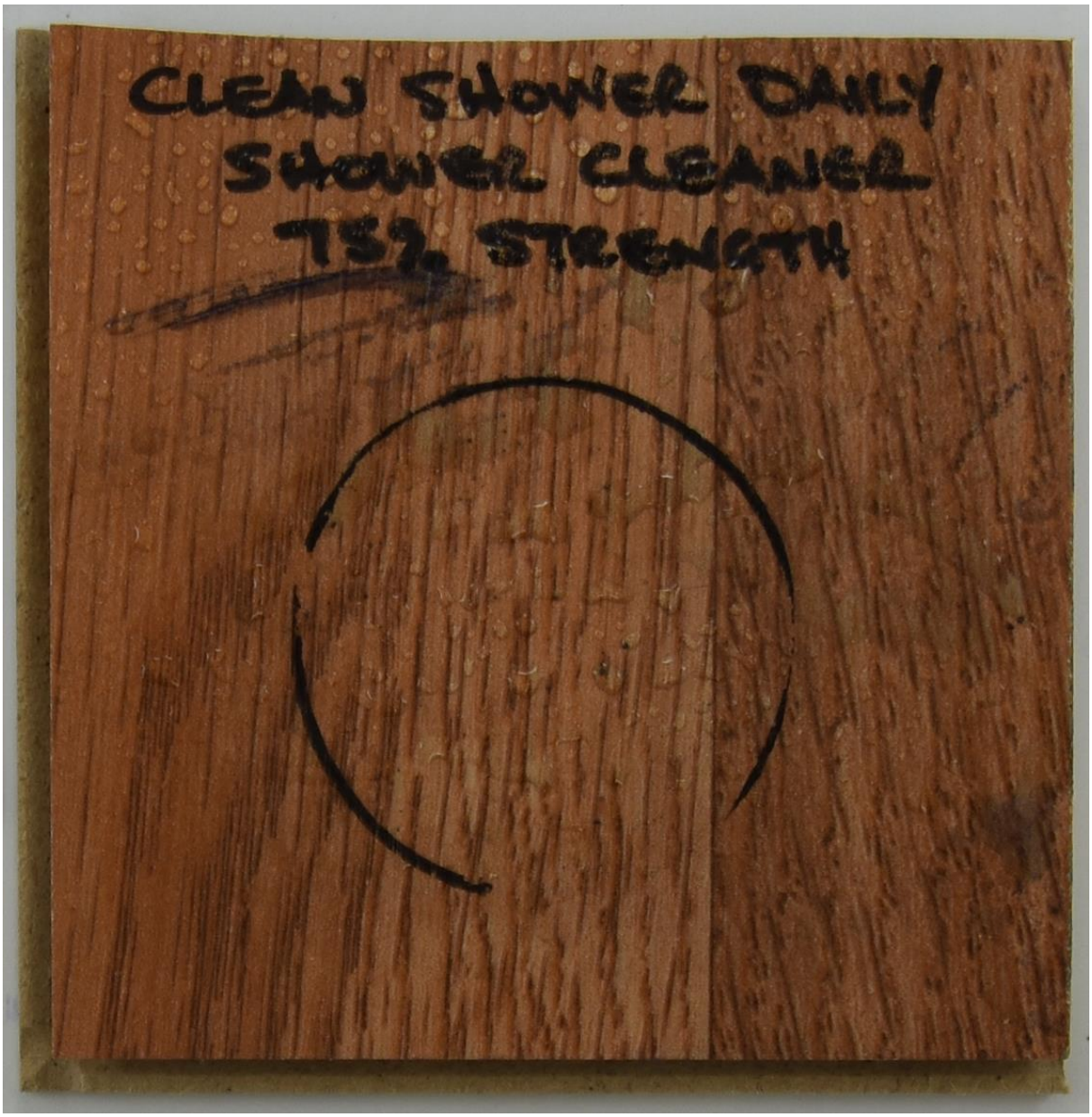

Figure 4

Laminated Wood Flooring Level 3 Reaction

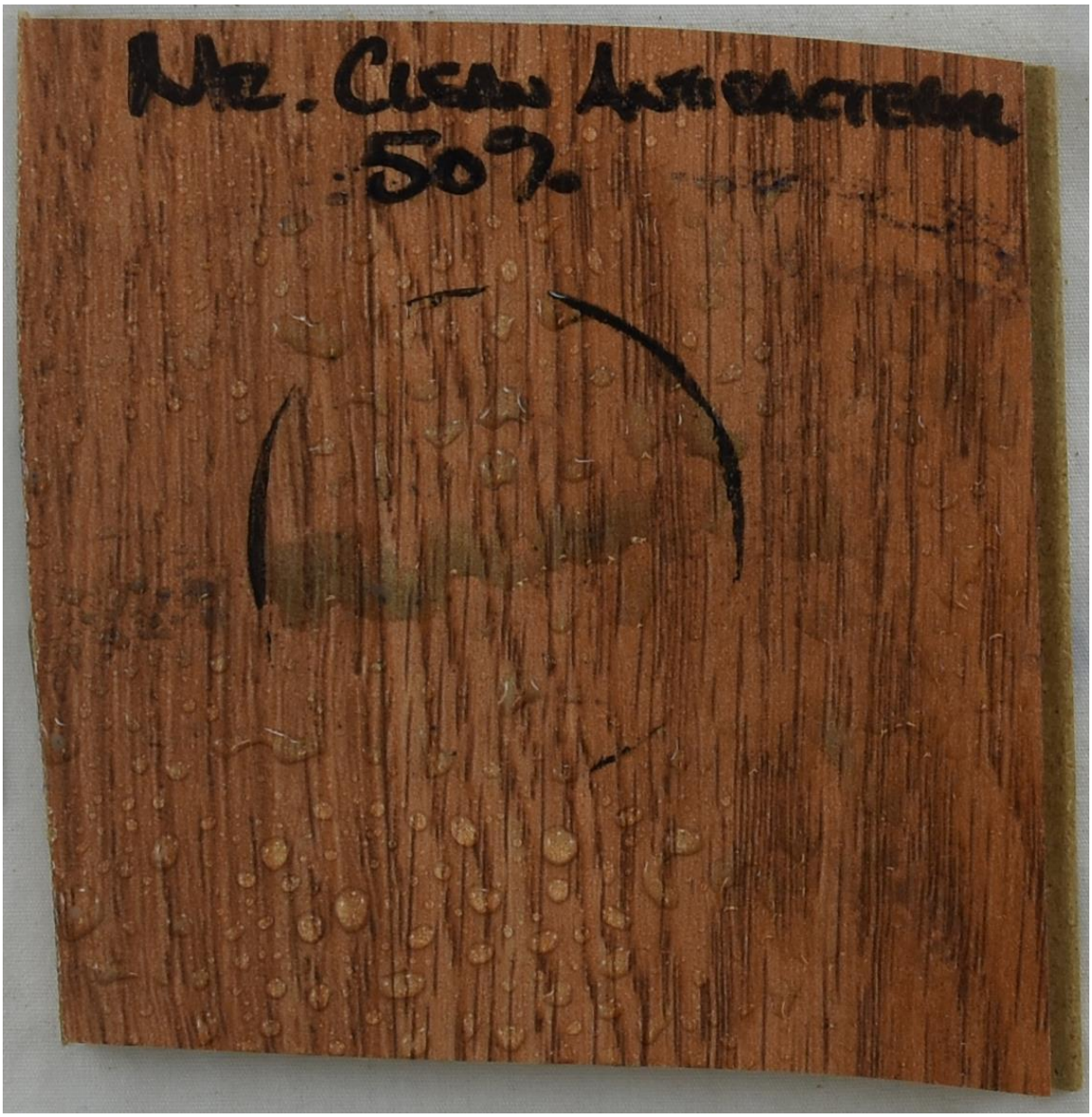

Figure 5

Laminated Wood Flooring Level 4 Reaction

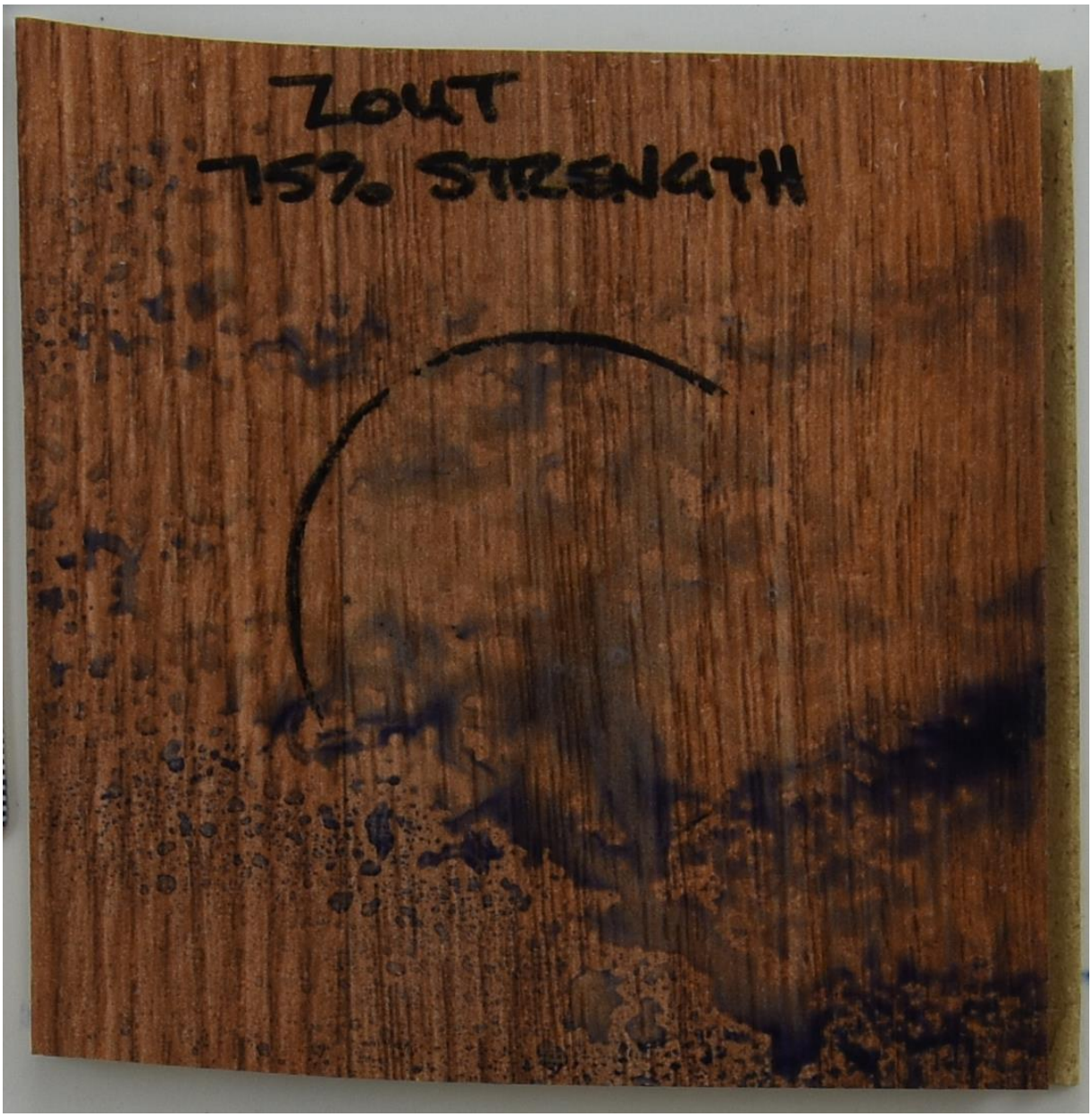

Figure 6

Linoleum Level 0 Reaction

Figure 7

Linoleum Level 1 Reaction

Figure 8

Linoleum Level 2 Reaction

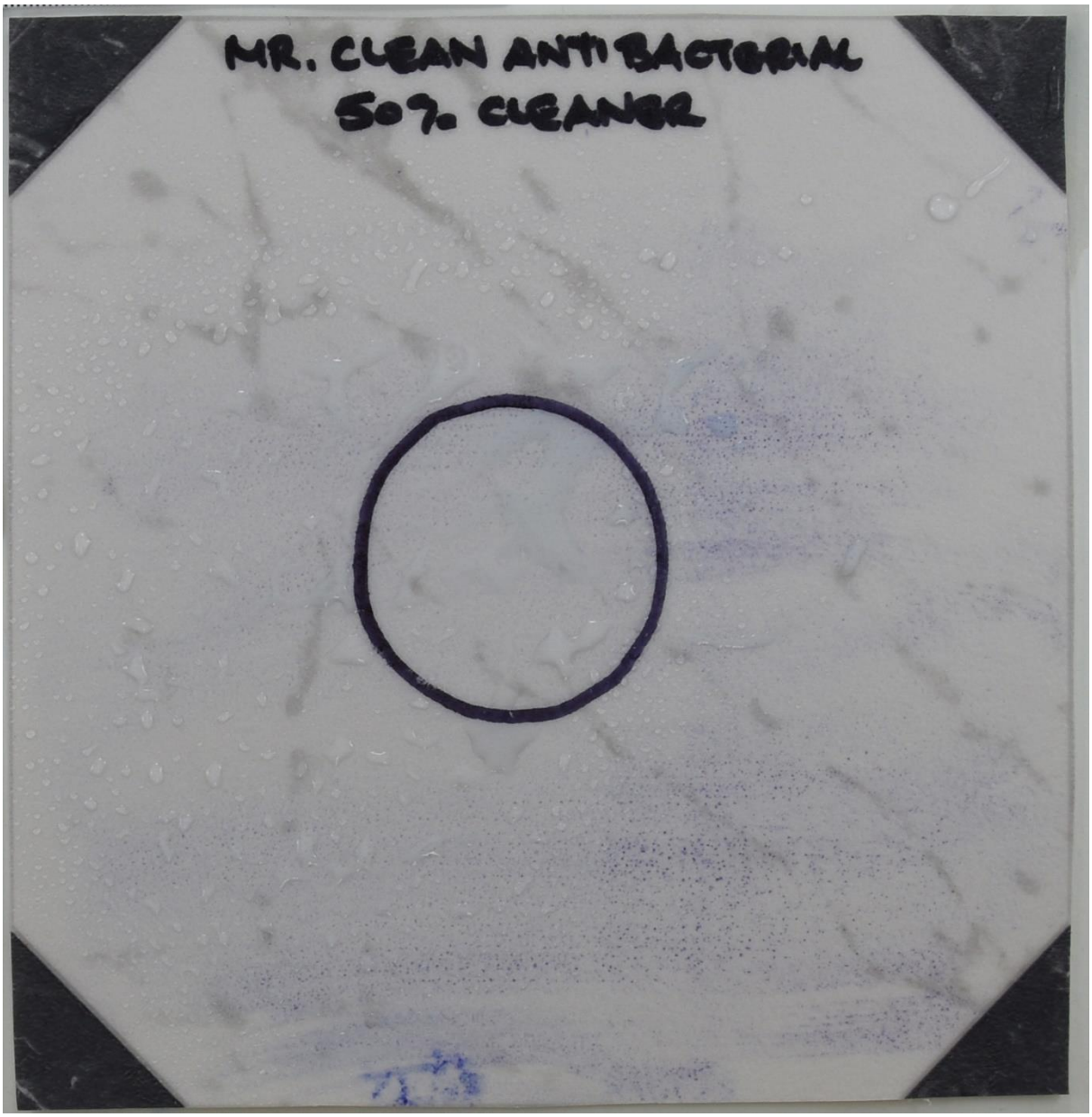

Figure 9

Linoleum Level 3 Reaction

Figure 10

Linoleum Level 4 Reaction

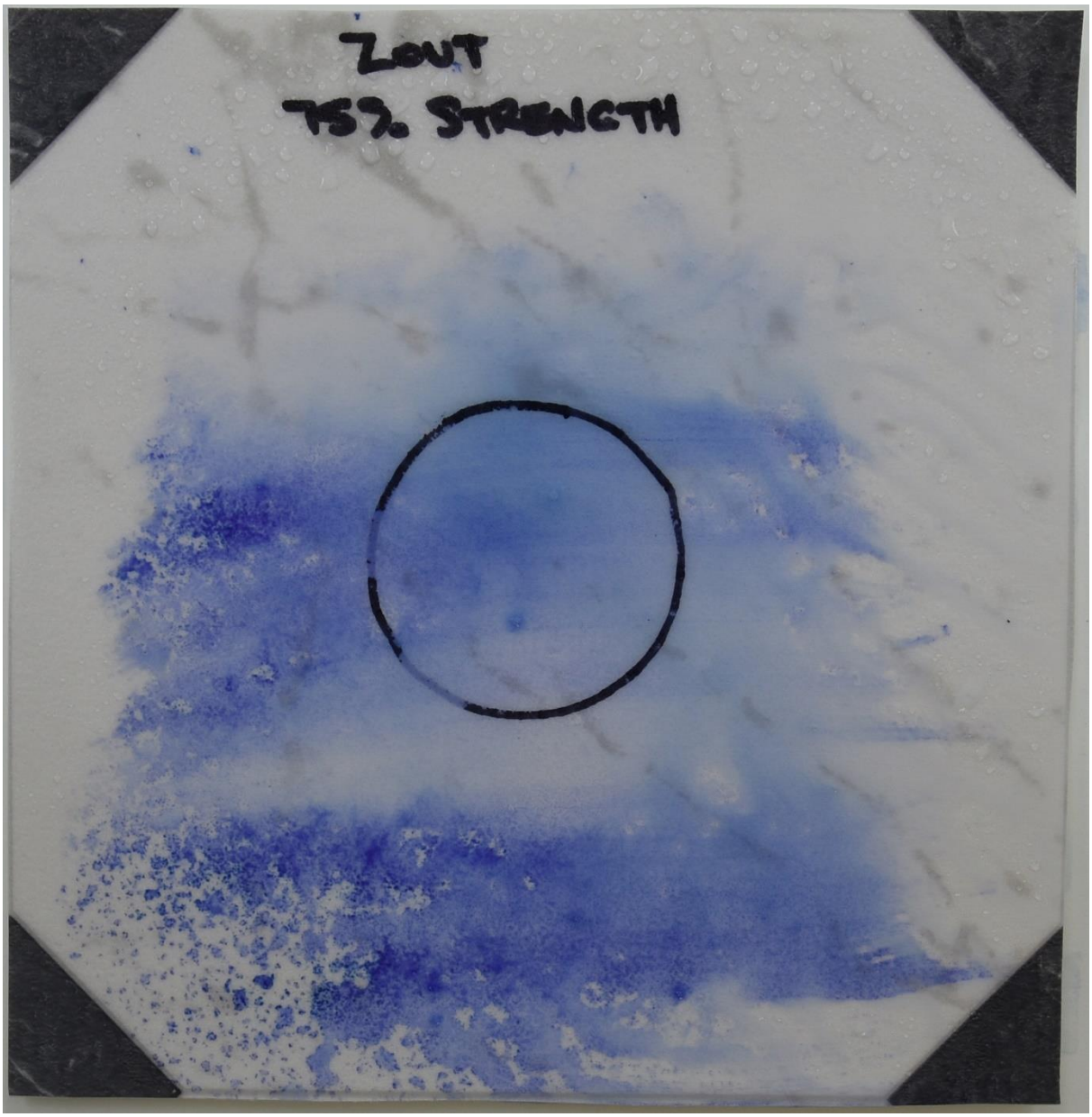

Figure 11

Painted Drywall Level 0 Reaction

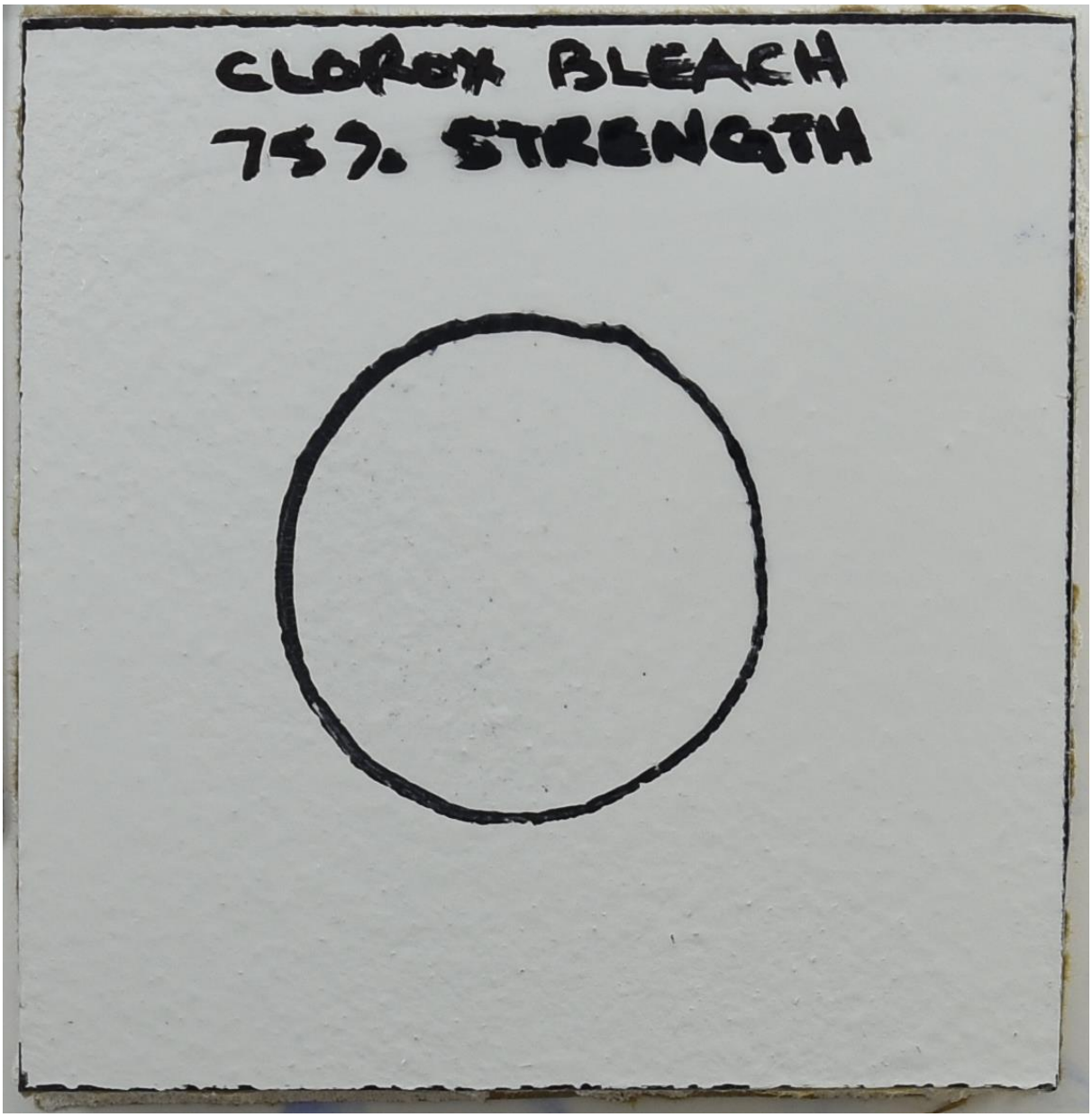

Figure 12

Painted Drywall Level 1 Reaction

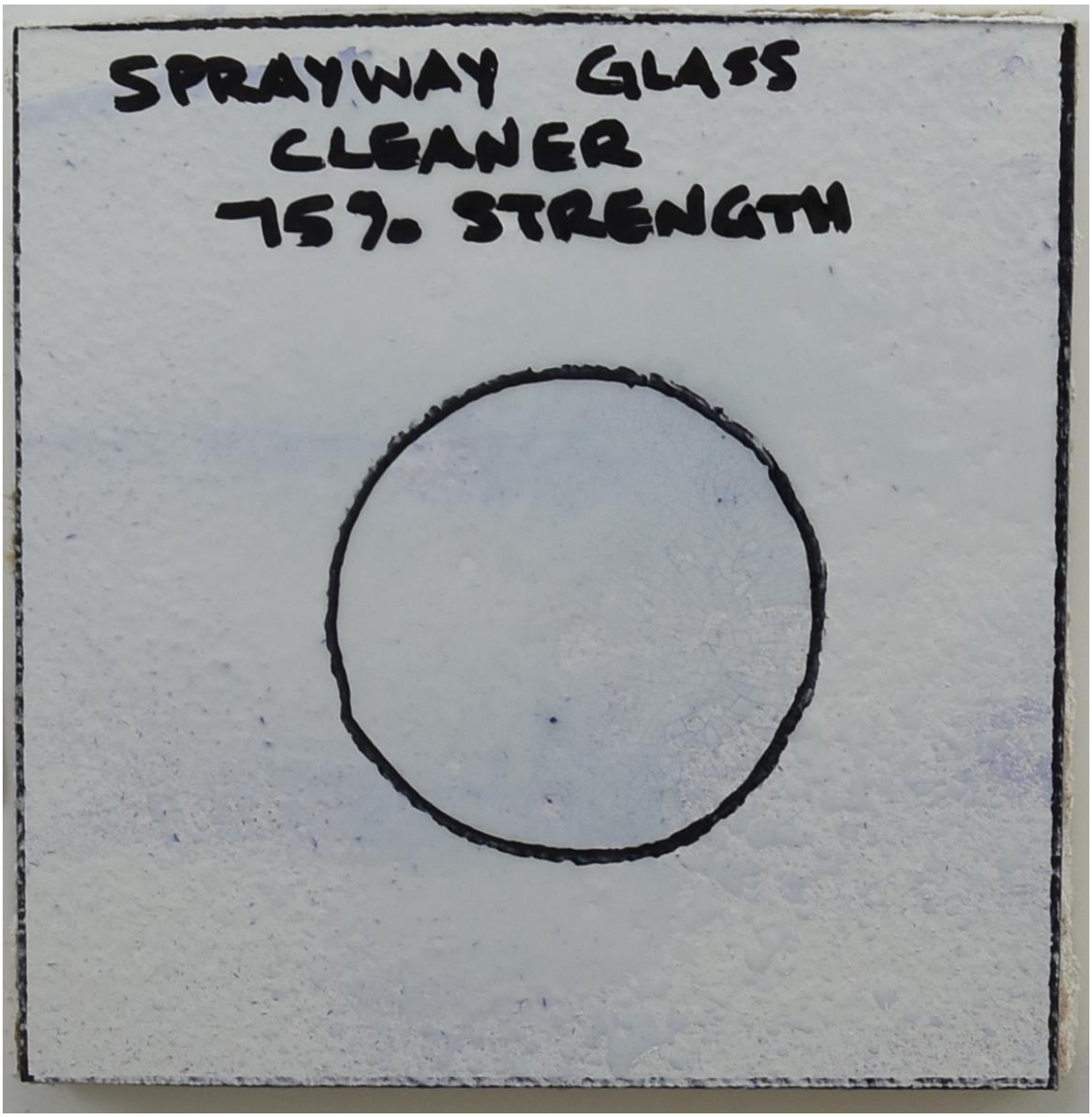

Figure 13

Painted Drywall Level 2 Reaction

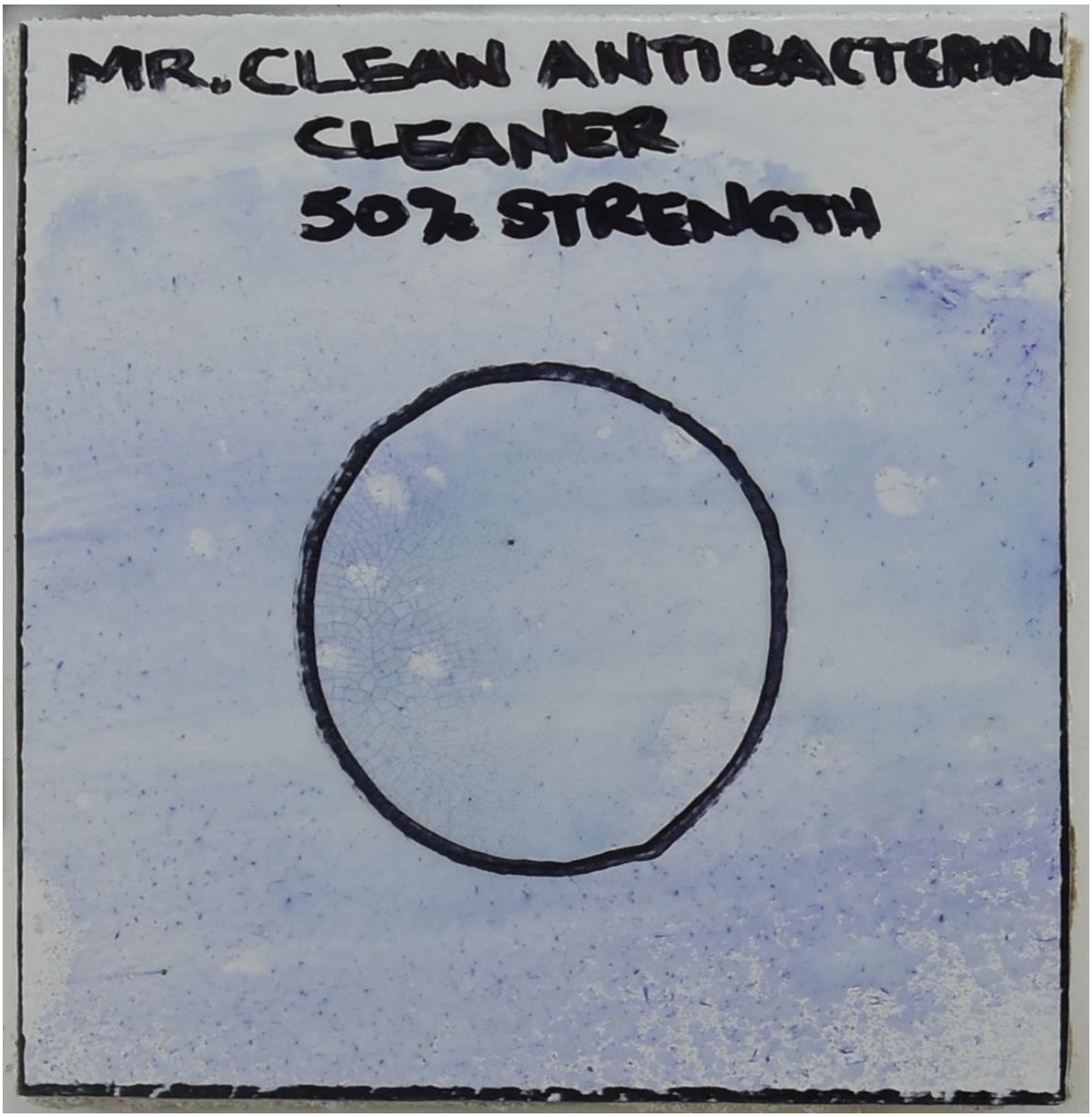

Figure 14

Painted Drywall Level 3 Reaction

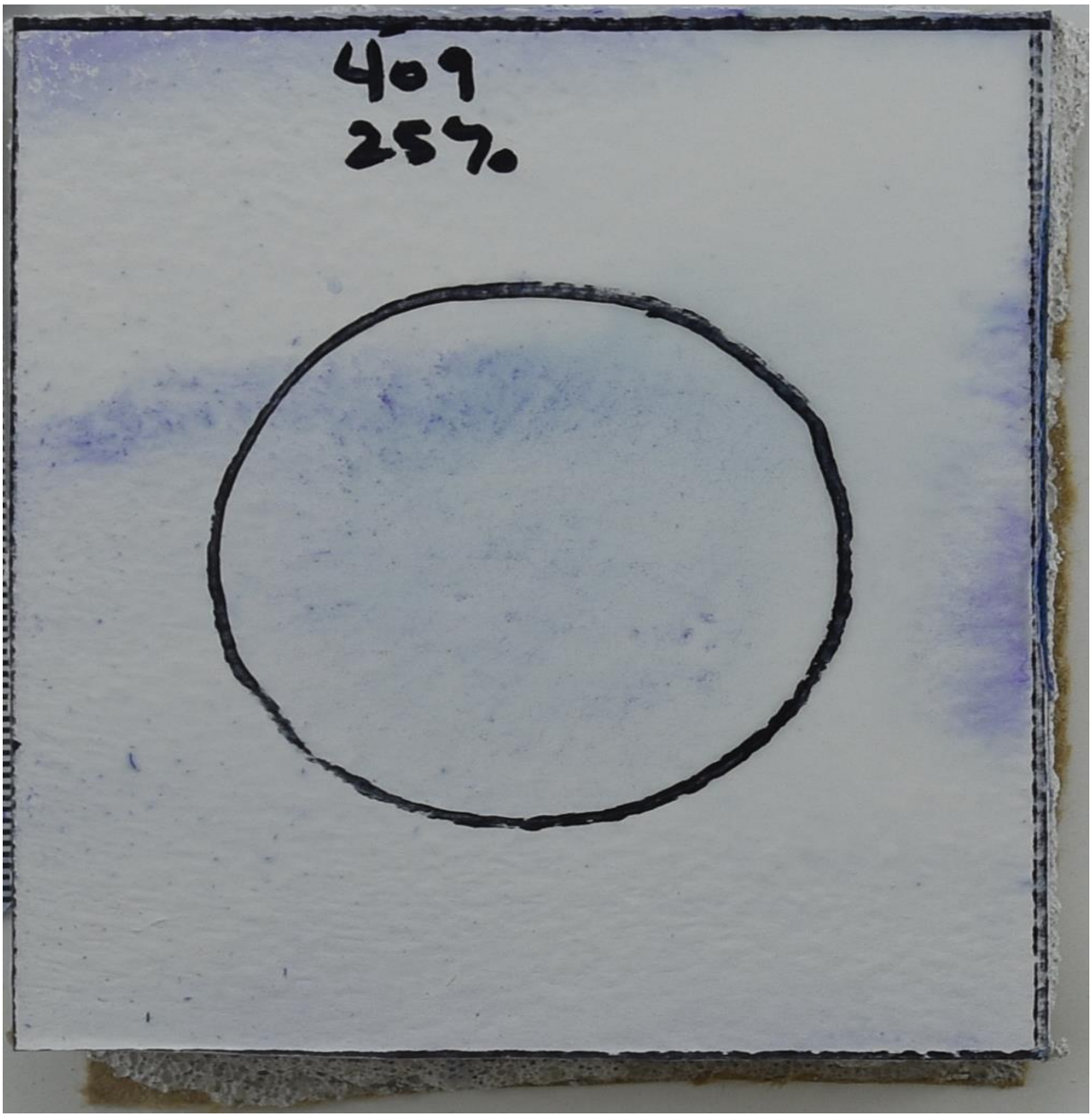

Figure 15

Painted Drywall Level 4 Reaction

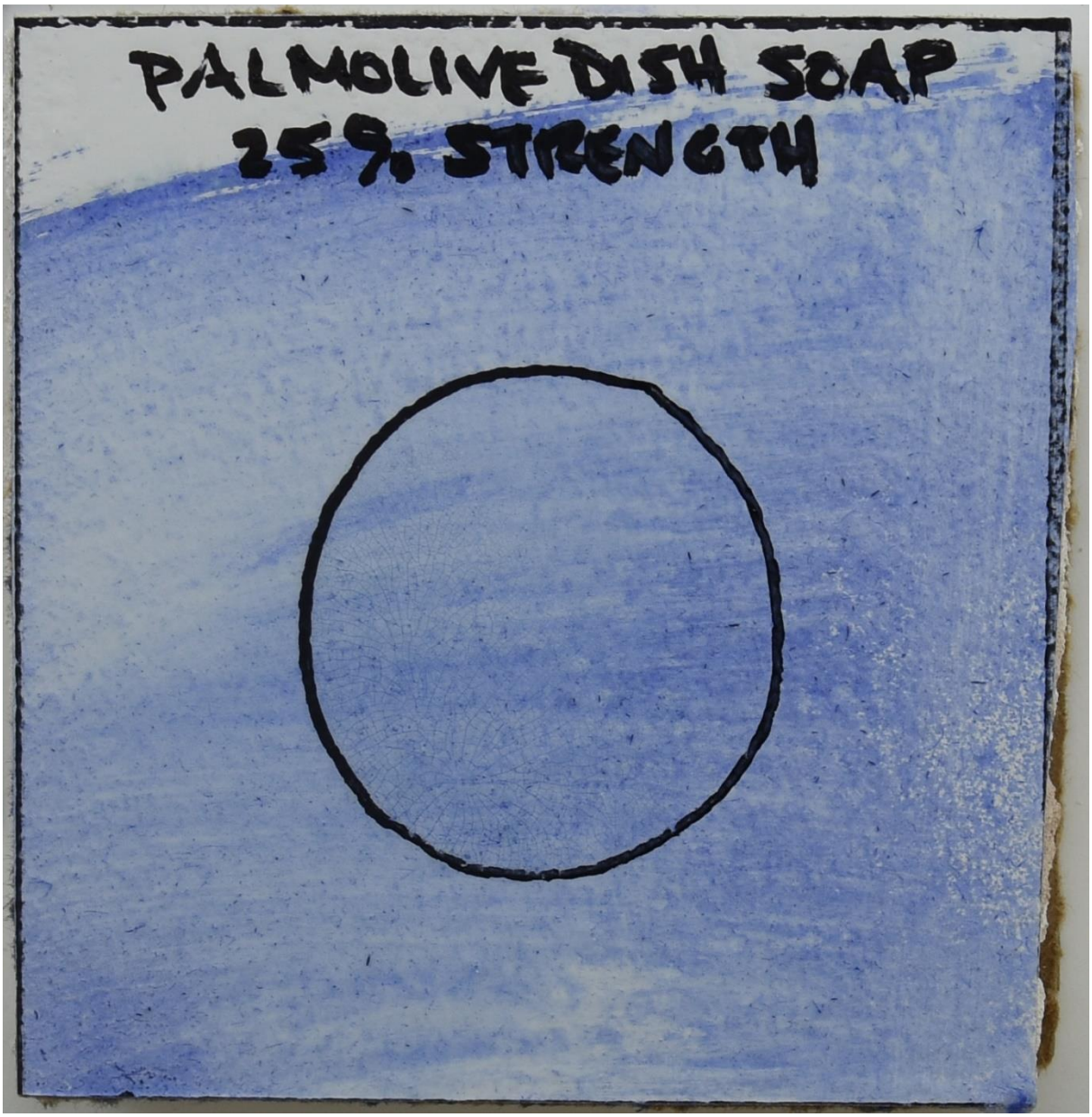

Figure 16

Painted Wooden Baseboard Level 1 Reaction

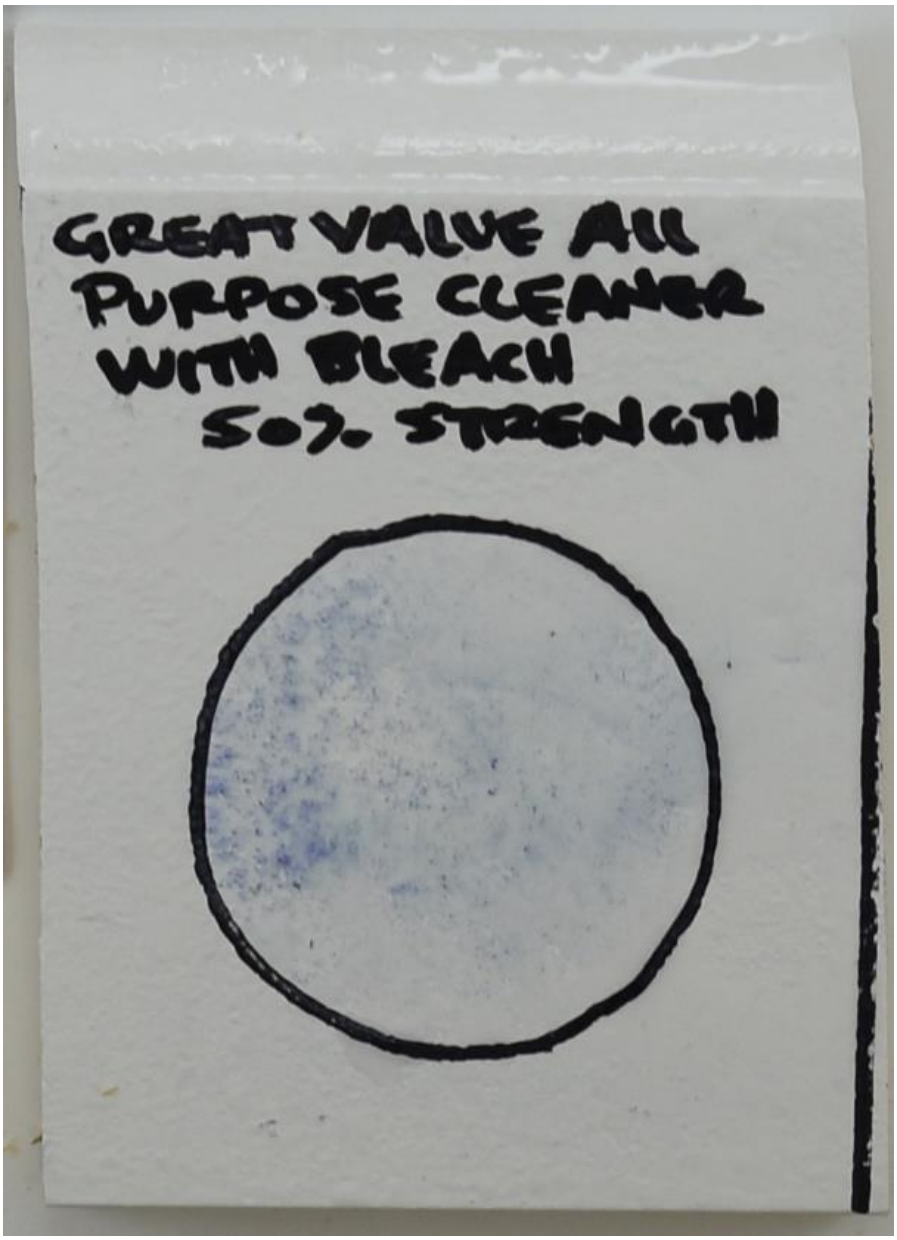

Figure 17

Painted Wooden Baseboard Level 2 Reaction

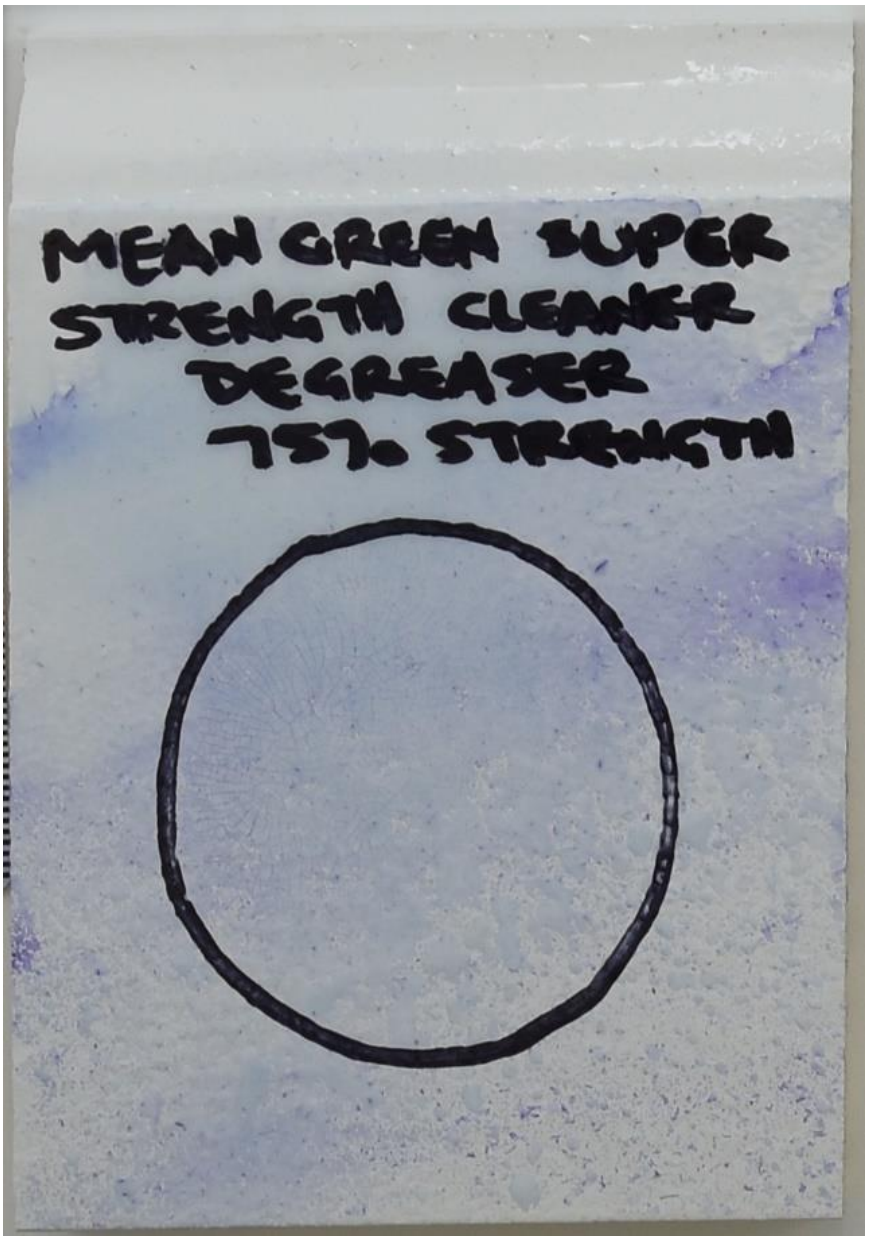

Figure 18

Painted Wooden Baseboard Level 3 Reaction

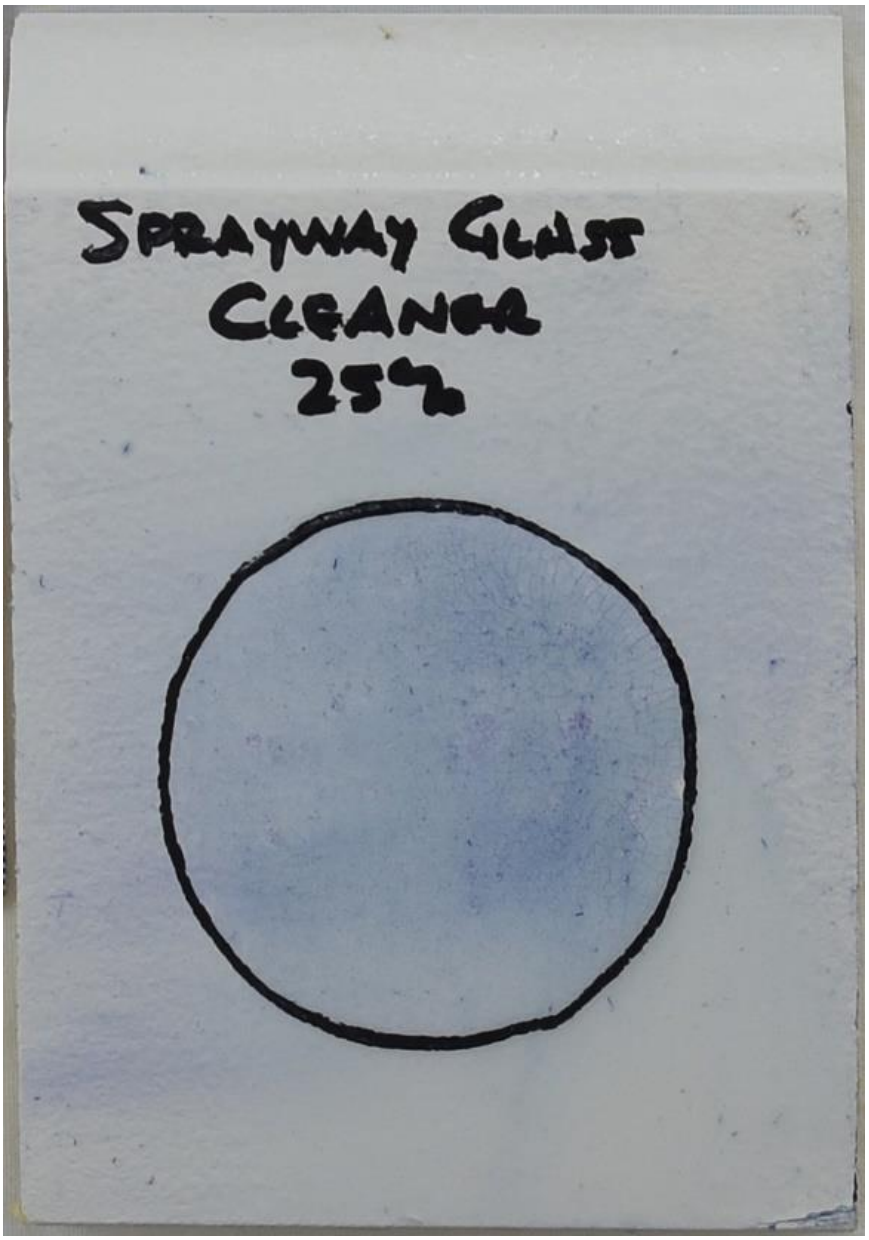

Figure 19

Painted Wooden Baseboard Level 4 Reaction

Figure 20

Porcelain Tile Level 0 Reaction

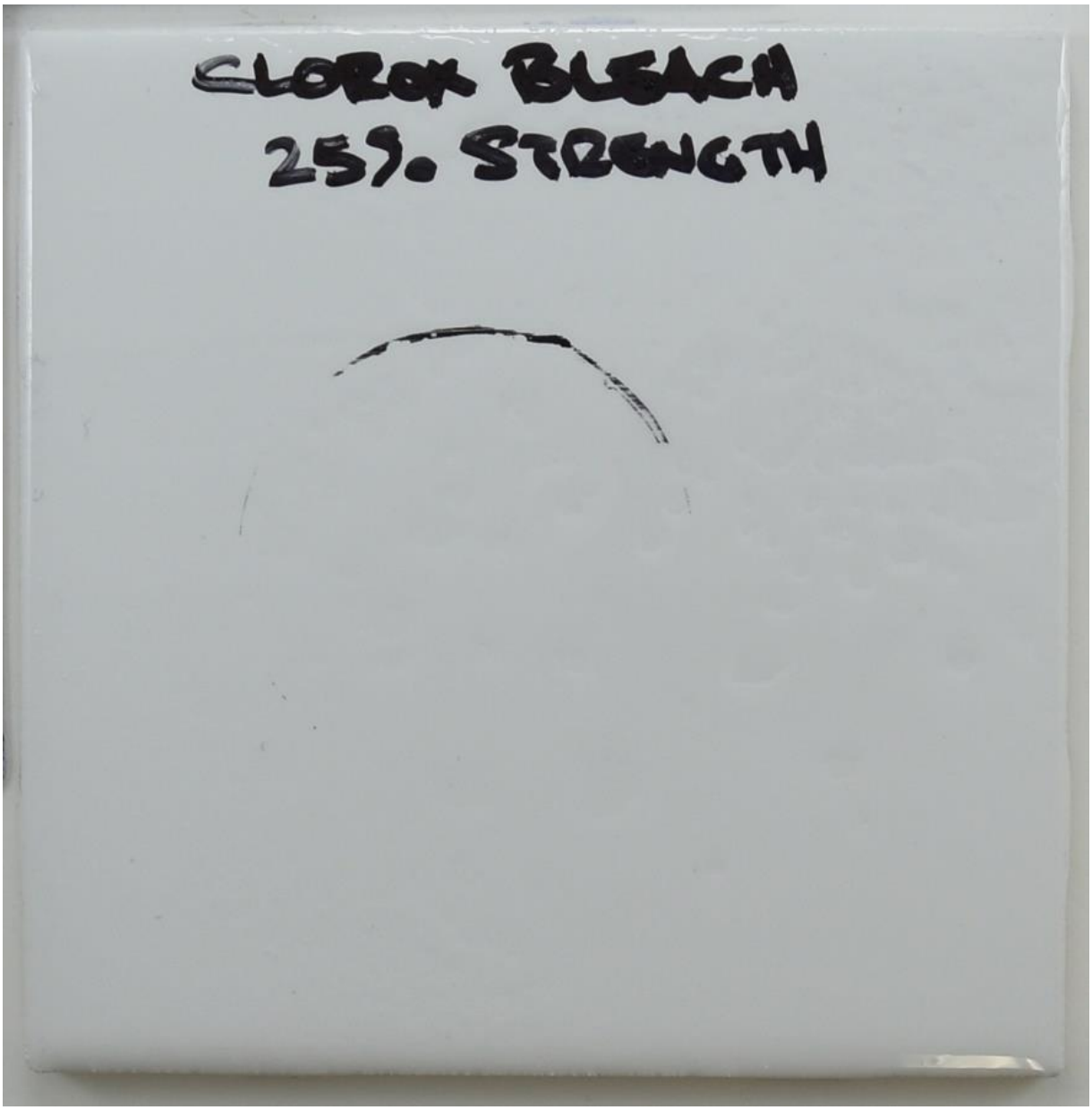

Figure 21

Porcelain Tile Level 1 Reaction

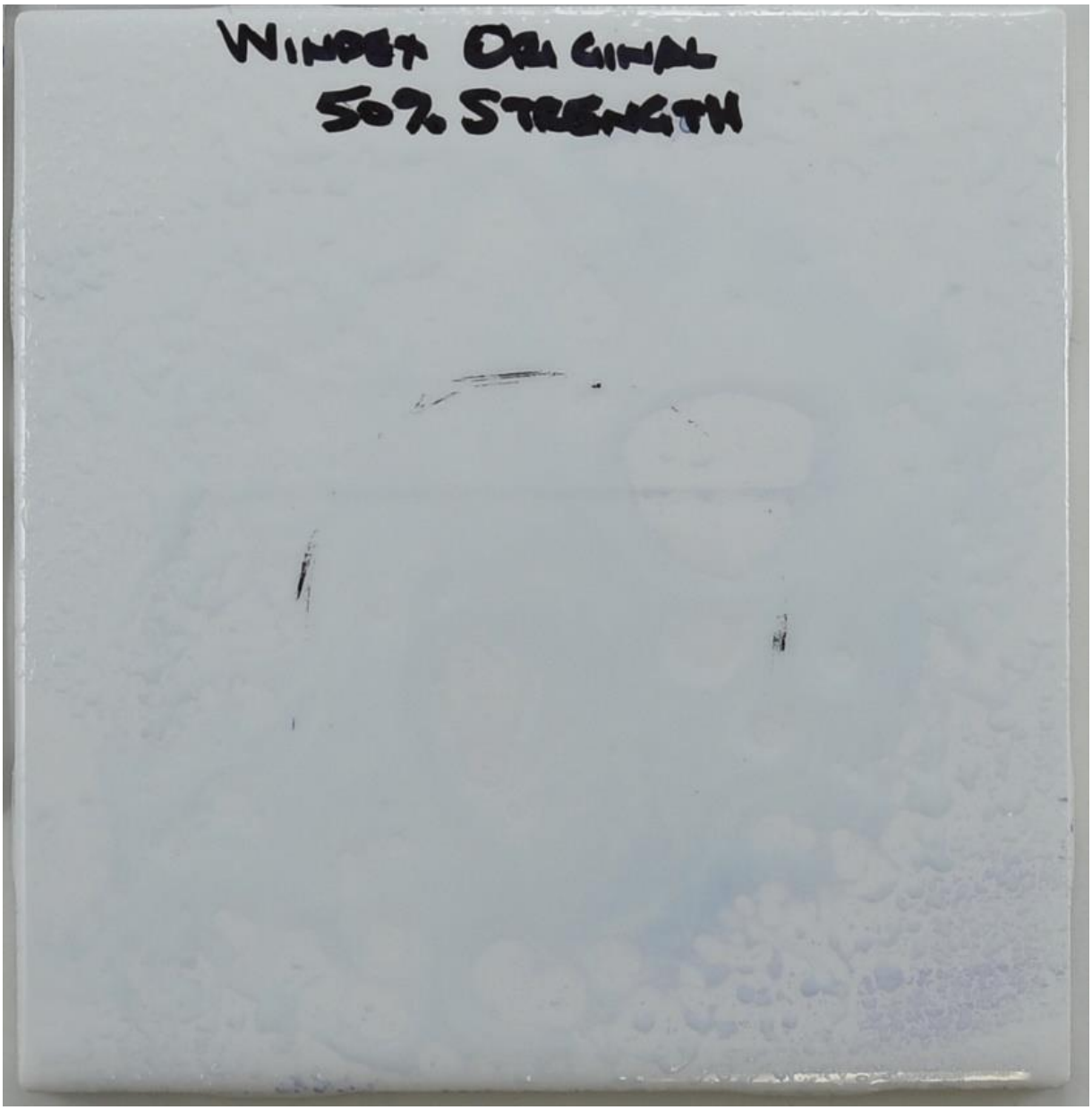

Figure 22

Porcelain Tile Level 2 Reaction

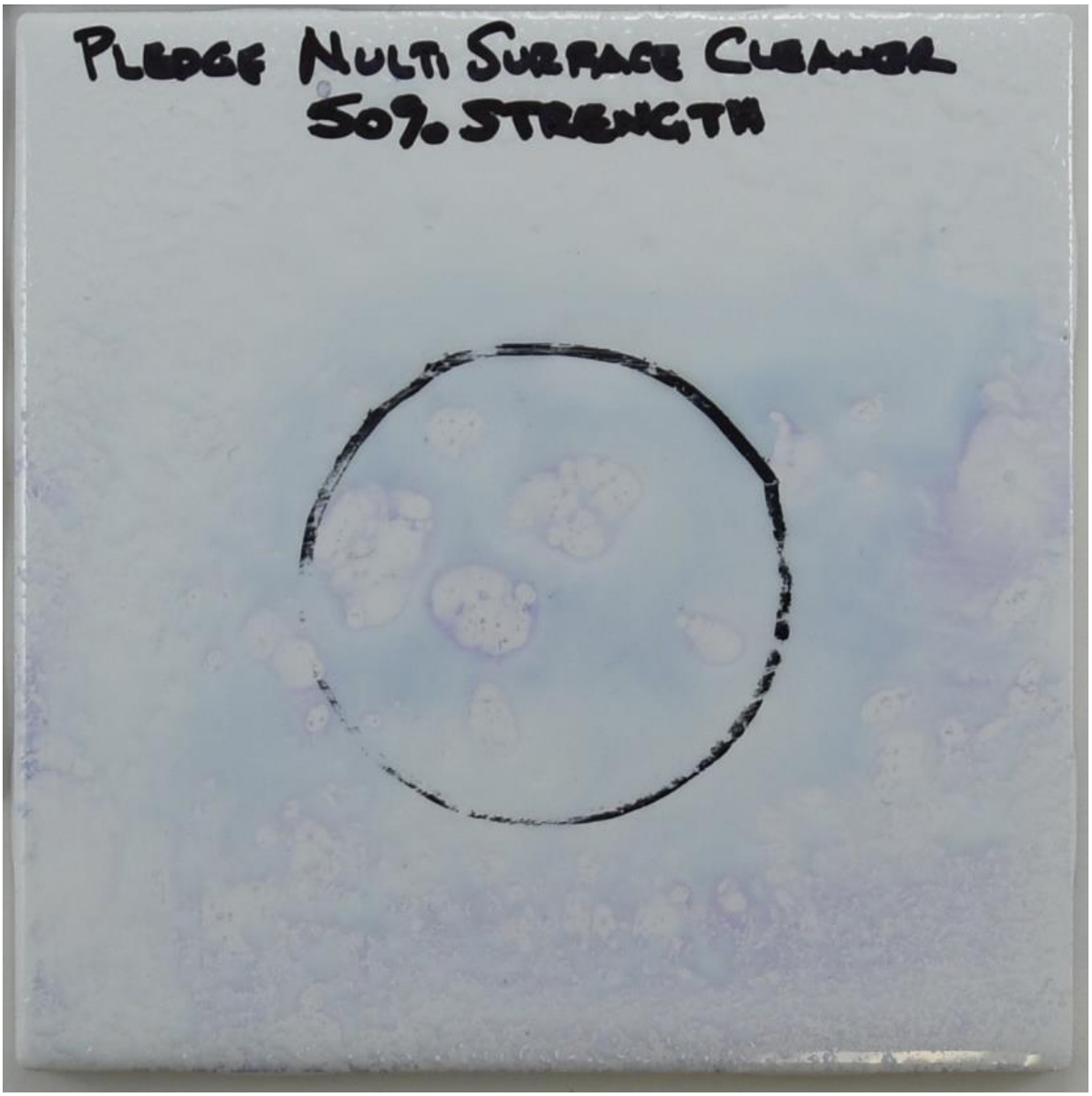

Figure 23

Porcelain Tile Level 3 Reaction

Figure 24

Porcelain Tile Level 4 Reaction

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