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# SURFACE AREA AS A METHOD FOR THE DETERMINATION OF GLOVE DEGRADATION

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# SURFACE AREA AS A METHOD FOR THE DETERMINATION OF GLOVE DEGRADATION

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A Thesis

Presented to the

Faculty of

California State University,

San Bernardino

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in

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by

Kandace May Steele

September 2014

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ABSTRACT

Gloves are an important aspect of personal protective equipment. They protect workers from chemical hazards as well as reduce the risk of exposure to infectious material. Chemical resistant gloves are made from a variety of polymer materials such as plastic, rubber, and synthetic rubber, as not one material provides protection against all chemicals. One type of polymer material may adequately protect against a specific chemical, but may not adequately protect against another. Experiments, such as degradation tests, are used to determine which material is most effective for each chemical tested. Current methods of degradation ratings are based on weight change, which can be expensive. The method described in this study provides an inexpensive alternative to gravimetric analysis. This method uses surface area change as a way to determine the degradation of a polymer material. The percent change data were compared between the weight change and the surface area change. The regression line given was $Y=0.4841x + 0.0187$ and the $R^2$ value was 0.9096. There is a strong correlation (Pearson $r = 0.9519$; $p \leq 0.05$) between percent weight change and percent surface area change. The Change for surface area is about half that of the weight change, which indicates that the surface area method is more sensitive than the gravimetric determination. Using this information, a rating system was developed for determining the degradation of gloves using surface area.

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# CHAPTER ONE

# PROJECT OVERVIEW

## Introduction

Personal protective equipment (PPE) is equipment worn to minimize exposure to a variety of hazards. PPE includes items such as goggles, hard hats, earplugs, respirators, foot protection and gloves.[1] Chemical resistant gloves are an important aspect of PPE. The skin can readily absorb many chemicals, and minor abrasions or cuts increase the odds of toxic chemicals entering the body. The skin is also sensitive to many chemicals that cannot be absorbed but repeated exposure could cause diseases such as dermatitis.[2] The best way to prevent exposure to these chemicals is by wearing the appropriate gloves, which involves selecting a polymer material that will resist chemical action. Many factors go into determining they best glove and polymer material to use. Some of these factors include, the chemical state and properties, environmental conditions, contact location, and resistance to physical stress[3].

Chemical protective gloves are made from a variety of polymer materials including rubber, plastic and synthetic rubber. Gloves are made from different materials because no one material will provide adequate protection from all chemicals.[4] A glove may adequately protect against a specific chemical, but may not adequately protect against another. An example of this is how different gloves react with acetone. Acetone has no effect on neoprene gloves, but nitrile

and vinyl gloves are not recommended for use with acetone.[5] To ensure that the proper gloves are selected for a specific chemical, a variety of testing is performed. The test methods provide insight into the effectiveness of a material's protection against a specific hazard. These tests include, permeation resistance, penetration resistance, and degradation resistance.[6] This current study evaluates degradation resistance.

Degradation is defined by the American Industrial Hygiene Association's *Chemical Protective Clothing*[7] as a change in the physical properties of a glove material caused by a chemical. These include but are not limited to swelling, shrinking, stiffness, wrinkling, and color change. The change in the physical properties of the glove by a chemical can significantly decrease the materials ability to prevent chemical exposure to the skin. The slower the degradation occurs, the more protective the material is for a specific chemical. Degradation ratings are an indicator of how well a glove will hold up when exposed to specific chemicals.

Various institutions have examined different approaches for measuring the degradation resistance of gloves, but no consistent testing method has been used in the United States or internationally that can apply to all PPE[5]. However, a variety of techniques are commonly used. The American Society for Testing and Materials (ASTM) F23 committee has established guidelines for determining the degradation ratings of gloves under the ASTM Method D471- *Standard Test Method for Rubber Property- Effect of liquids.*[8] This method

covers the procedures necessary to evaluate and compare the ability of a rubber/rubber-like material to hold up to a specific liquid. It is designed specifically for testing rubber cut from standard sheets, and strips cuts from fabric coated with rubber.

ASTM Method D471[8] provides procedures for exposing test samples to the influence of liquids under specific conditions of time and temperature. This test method uses a gravimetric analysis to evaluate weight change. The weight is determined for each sample before it is exposed and after exposure to a chemical. The percent weight change is then calculated. In order to perform this test method an analytical balance is required. These balances are expensive, and can cost thousands of dollars.[9] Do to the cost; this method may not be a viable option for many organizations, e.g., small businesses, to determine the most appropriate glove to use for a specific chemical. If a company or employer cannot run degradation tests of their own, they must reply on others for this information. Unfortunately, degradation data are not readily available for most commercial products, or pure chemicals as well.

Degradation ratings have been performed for a variety of chemicals and glove products. Results of these tests can be seen in the *Ansell Guide to Chemical Resistance 8th Edition.*[5] This guide provides a great reference for determining the best Ansell glove to use for the chemicals they tested. However, only pure chemicals are primarily used in their testing. Mixtures or commercial products are rarely tested. Also, only a limited number of chemicals have been

tested. *The Ansell Chemical Resistance Guide 8th Edition*[5] only covers 167 different chemicals. There are other glove manufacturer chemical resistance guides, but most are also limited in scope and similar to those prepared by Ansell Edmont. Examples of glove manufacturers that also produce chemical resistance guides include: ShowBest, Kimberly-Clark and North.[10] However, the same issues exist with these guides.

If the chemical being used is not on the glove manufacturer's list, then one would have to rely on the safety data sheets (SDS) or other sources, such as a chemical technical data sheet. However, many SDSs are not very specific on the types of gloves that should be worn. Many SDSs state that gloves are recommended but do not state the specific polymer types of gloves that are best suited for use with that particular chemical.

Because only a minimal amount of chemicals are tested on with gloves, there is a limited amount of information provided by SDSs, and due to the expense of degradation testing; a more efficient and cost-effective method needs to be developed. An inexpensive method would allow smaller companies, and even individuals to do degradation testing of the specific chemicals and commercial products they use and are exposed to on a daily basis. This would aid in a more accurate selection of appropriate PPE, which in turn would keep those exposed to chemicals safer.

## Purpose of Study

The purpose of this study is to determine if surface area percent change is a valid method of determining glove degradation, and if so to then develop a degradation rating system for this method. This alternate method is to be developed as an inexpensive alternative to the current method of determining glove degradation based on weight change. The current method, ASTM Method D 471[8], requires the use of an expensive analytical balance in order to determine the weight percent change. For employers or companies that do not use scientific balances on a regular basis, purchasing one specifically for this purpose is costly and may not be an option. For this new method, all that is needed is a digital scanner (standard office equipment) and the National Institutes of Health (NIH) ImageJ software, which is free and available for download at http://rsb.info.nih.gov/ij/.[11]

The Occupational Safety and Health Administration (OSHA) requires employers to select and use appropriate PPE when employees are exposed to hazards such as those that can be absorbed by the skin.[12] Employers are to make selections on appropriate PPE based on the performance of the PPE relative to the task being performed, the conditions under which the task is being performed, duration of use, and the potential hazard itself. In the case of chemical resistant gloves as PPE, many employers can use guidelines and charts similar to the *Ansell Chemical Resistance Guide*[5] to determine the appropriate glove for their employees based on the chemical they will be

exposed to. However, not every chemical a worker may be exposed to has been tested, and only pure chemicals are often tested. Many of the chemicals workers are exposed to are mixtures, as with many available commercial products. This causes a problem for determining the appropriate PPE to be worn by the employees. Therefore an inexpensive and simple method for determining glove degradation needs to be developed. This would allow each employer to test different types of glove materials and/or products using the specific chemicals the employees are using and exposed to. This would give the employers a better idea of the appropriate glove to select for their employees.

## Limitations of Study

There are a few limitations to this study that should be addressed. One of these limitations is that this study was conducted under laboratory conditions. The conditions in the workplace would be far more complex and may affect the glove degradation. Other factors such as the gloves resistance to punctures, stretching, abrasions, and cuts should be taken into consideration. Other limitations include sample size of both the types of gloves tested and chemicals of which they were tested in. Only 5 different types of gloves were tested in contact with 50 different chemicals. Chemicals were selected to represent a wide variety of commercial products, but there may be exceptions to the general results presented here. Lastly, there is a lack of prior research studies on this topic.

# CHAPTER TWO

# MATERIALS AND METHODS

## Polymer Materials

Five different types of polymer materials were chosen for this study. The polymers chosen were neoprene, butyl rubber, nitrile, polyvinyl chloride (vinyl), and natural latex (herein referred to as latex). These five were selected based on the following criteria: commonly used in industry, sold and tested by Ansell Edmont and other glove manufacturers, and all have a wide range of chemicals they are recommended for. For example, butyl rubber is recommended for use against ketones esters, and glycol ethers, but is a poor choice for use against hydrocarbons and chlorinated solvents.[13] Nitrile, on the other hand, is not recommended for use against ketones, but is recommended for use against oils, grease, and aliphatic chemicals.[13] This variety of uses was selected to help ensure that at least one polymer material would show no degradation signs while others would show significant changes. This also allows for a better comparison between the surface area and gravimetric test methods for degradation.

The polymer materials for neoprene, butyl, nitrile, and vinyl were 1/16th of an inch (0.16 cm) thick, and came in sheets of 3x5 feet (.91x1.5m) from MSC Industrial (Melville, NY). The latex material was 1/32 inch (0.08 cm) thick and came from Marigold W.W. Grainger, Inc ( Chicago, IL) model number 326Y.

Each polymer material was cut into strips using a 3.0 x0.5 inch (7.63x1.27cm) die (W.R. Sharples, North Attleboro, MA).

## Chemicals

A variety of 50 different chemicals were selected for this study, see Table 1. The chemical mixtures were composed of chemicals the average person may use such as cleansers, pool chemicals, wood strippers, and automotive related chemicals. These chemicals were selected to ensure this study would benefit workers and employers who would be using some of these common chemical hazards. Another consideration was cost. Facility Services at California State University San Bernardino donated the majority of these chemicals. Many of these chemicals, based on their SDSs, were known to be caustic and in some cases only one glove was recommended for use. So it was concluded that some of them chemicals would effect the gloves where as others would not, making the chemical selection ideal for this study.

Table 1. Chemical List

| | | | | |
|---|---|---|---|---|
| 1.Diversey: Speed Track-Clean & Burnish Fragrance Free | 11.Resolve: Triple oxy Advance | 21.Hercules: Sizzle | 31.Ecoline: Dry Teflon | 41.Valvoline: Heavy Duty Break Parts cleaner |
| 2.Practical Solutions: PowerBolt Spray | 12.Hoxmax: Oops Amazing Remover | 22.MT: Penetrating oil | 32.Ecolab: Oasis 266 | 42.Valvoline: Dot 3&4 |
| 3.Practical Solutions: Reflecta Neutral Floor Cleaner | 13.HTH: Super Algea Guard | 23.MT: Cold Shield | 33.Maxima: Chain Wax | 43.Easy Off: Oven Cleaner |
| 4.Practical Solutions: Non Acidic Washroom Cleaner Conc. | 14.Aqua Chem: Super Water Clarifier | 24.Winner Industrial Supply: EZ Seal | 34.WD-40 | 44.Liquid Plumber: Hair Clog Eliminator |
| 5.Diversey: Speedball 200-Heavy Duty Spray Cleaner | 15.Jasco: Varnish & Stain Remover | 25.Oaty: Abs Cement | 35.Kingsford: Charcoal Lighter Fluid | 45.Amazing!: Liquid Fire |
| 6.Diversey: Virex II 256 One Step Disinfectant Cleaner and Deodorant | 16.Sevin: Concentrated Bug Killer | 26.Clorox: Germicidal Bleach | 36.Henry: Easy Release Adhesive Remover | 46.Clorox: Outdoor bleach |
| 7.Diversey: Foaming Acid Restroom Cleaner | 17.Jasco: Paint & Apoxy Cleaner | 27.Simply Green: All Purpose Cleaner | 37.Sweeney's: Mole and Gopher Repellant | 47.Resolve: Spray and Wash Laundry Stain Remover |
| 8.Romans Golden Harvest: Strip+ Wall Paper & Paste Remover | 18.Ranger: Pro Herbicide | 28.Nexgen Chemstar Line: Nexbac | 38.Liquid Performance: Spray Cleaner and Polish | 48.White Lightning: Cleans Streak |
| 9.Clorox: 409 All Purpose Cleaner | 19.Kimball Midwest: Inter-Lube Penetrating Grease | 29.Relton: Rapid Tap | 39.TrueFuel: Trufuel 40:1 Engineered Fuel + Oil | 49.Turtle Wax: Bug and Tar Remover |
| 10.Armstrong: Tile and Vinyl Floor Cleaner | 20.Olympus: Hydraulic Oil | 30.Weld-on P-70 Primer | 40.Craftmen: Fuel Stabilizer | 50. 3-IN-ONE: Motor Oil |

## Methodology

Degradation, based on weight, was measured in accordance to ASTM Method D 471 *Standard test method for Rubber Property-Effects of Liquids (8)*, with the exceptions that testing was done at room temperature and the total exposure period was 24 hours.

### Pre Treatment

Three samples per type of polymer were exposed to each chemical. The samples were inspected for any tears or other abnormalities. Once deemed acceptable for use, each polymer sample was weighed individually on a Fisher Scientific Model ALF104 (Los Angeles, CA) analytical balance with 0.0001g readability. The values were recorded and each sample was placed in a marked envelope to insure the samples were not mixed up. The thickness was then measured using a Marathon Management CO 030025 Electronic Digital Micrometer (range 0-25mm) supplied by Fisher Scientific (Los Angeles, CA). Each sample was measured three times and the average thickness was calculated. Samples were then scanned into ImageJ using a Brother Industries Fax/Scan/Copy Machine Model number MFC-7340 (Office Max, San Bernardino, CA). The ImageJ software was used to determine the surface area of each polymer sample. The software measured surface area in pixels and then it was converted to $cm^2$, using the set scale of 118.11 pixels/cm, based on laboratory measurements.

Treatment

After the initial measurements were completed, the three polymer samples were carefully placed into 15 mL glass vials. The selected chemical was then poured into the vile containing the samples. The polymers were separated using tweezers to insure the samples were fully coated by the selected chemical. The samples were submerged for 24 hours. The samples were kept at room temperature for the entirety of the treatment process.

Post Treatment

After the allotted time, the gloves were removed from the vials, and dried with a paper towel. The weight, thickness and surface area were then determined using the same methods as described above. Once the values were determined the percent change for weight, thickness, and surface area were calculated, using the following formula.

$$\text{Percent Change} = \frac{(\text{Final Value} - \text{Initial Value})}{\text{Initial Value}} x100$$

# CHAPTER THREE

# FINDINGS AND RESULTS

Statistical analyses were performed using Microsoft Excel. Student *t* tests were run to determine the significance of the changes for weight, thickness and surface area. Results were considered significant if the *p* value was less than 0.05. A correlation and regression analysis was also performed to compare the percent change of weight to the percent change of surface area for those samples that had significant change. The data are provided in Table 2 and Figure 1.

The significant percent change, when comparing weight and surface area, was often consistent between the two measures. When there was a change seen in weight there was a change seen in surface area. This is the same for the changes that were deemed not significant. In a majority of the tests (82.3%), when there is no significant change in weight change there is no significant change in surface area. However, in a few cases (17.7%), there is a significant change in the weight change but no significant change in surface area. An example of this can be seen in Table 2 for chemical 2.

Table 2. Statistical Data for All Polymer and Chemical Combinations

Chemical 1

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.288 | 2.307 | 1.694 | 1.714 | 10.058 | 10.113 |
| | SD | 0.008 | 0.009 | 0.009 | 0.018 | 0.053 | 0.101 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.075 | 2.089 | 1.607 | 1.609 | 10.076 | 10.103 |
| | SD | 0.006 | 0.006 | 0.004 | 0.008 | 0.033 | 0.044 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.387 | 2.412 | 1.697 | 1.681 | 10.113 | 10.080 |
| | SD | 0.022 | 0.021 | 0.006 | 0.017 | 0.114 | 0.118 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.279 | 2.308 | 1.589 | 1.599 | 10.708 | 10.758 |
| | SD | 0.059 | 0.060 | 0.011 | 0.020 | 0.214 | 0.145 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.222 | 1.245 | 1.136 | 1.154 | 10.430 | 10.730 |
| | SD | 0.009 | 0.009 | 0.109 | 0.109 | 0.272 | 0.799 |
| | Percent Change | 1.87% | | 1.58% | | 2.88% | |

Chemical 2

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.274 | 2.318 | 1.714 | 1.714 | 9.990 | 10.084 |
| | SD | 0.024 | 0.024 | 0.015 | 0.015 | 0.210 | 0.126 |
| | Percent Change | 1.96% | | 1.68% | | NS | |
| 2 | Mean | 2.070 | 2.103 | 1.600 | 1.617 | 10.111 | 10.118 |
| | SD | 0.009 | 0.011 | 0.016 | 0.010 | 0.023 | 0.020 |
| | Percent Change | 1.57% | | NS | | 1.04% | |
| 3 | Mean | 2.423 | 2.462 | 1.711 | 1.700 | 10.093 | 10.140 |
| | SD | 0.029 | 0.011 | 0.008 | 0.016 | 0.182 | 0.178 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.365 | 2.418 | 1.644 | 1.646 | 10.937 | 10.794 |
| | SD | 0.156 | 0.161 | 0.041 | 0.045 | 0.321 | 0.518 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.179 | 1.482 | 1.136 | 1.164 | 10.520 | 10.525 |
| | SD | 0.056 | 0.068 | 0.109 | 0.085 | 0.164 | 0.164 |
| | Percent Change | 0.257 | | NS | | 2.41% | |

Table 2. Continued

Chemical 3

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.282 | 2.315 | 1.691 | 1.710 | 9.985 | 10.042 |
| | SD | 0.016 | 0.015 | 0.014 | 0.015 | 0.071 | 0.143 |
| | Percent Change | 1.43% | | 1.09% | | NS | |
| 2 | Mean | 2.074 | 2.090 | 1.605 | 1.623 | 10.157 | 10.202 |
| | SD | 0.015 | 0.015 | 0.006 | 0.003 | 0.110 | 0.000 |
| | Percent Change | 0.78% | | 1.08% | | NS | |
| 3 | Mean | 2.418 | 2.466 | 1.716 | 1.712 | 9.838 | 10.076 |
| | SD | 0.028 | 0.065 | 0.002 | 0.017 | 0.108 | 0.118 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.339 | 2.303 | 1.680 | 1.667 | 10.635 | 10.634 |
| | SD | 0.087 | 0.153 | 0.057 | 0.033 | 0.282 | 0.283 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.186 | 1.257 | 1.083 | 1.122 | 10.563 | 10.571 |
| | SD | 0.158 | 0.163 | 0.121 | 0.125 | 0.077 | 0.076 |
| | Percent Change | 5.99% | | 3.60% | | 0.08% | |

Chemical 4

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.282 | 2.287 | 1.700 | 1.700 | 10.001 | 10.018 |
| | SD | 0.050 | 0.050 | 0.035 | 0.033 | 0.122 | 0.104 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.082 | 2.100 | 1.606 | 1.626 | 10.126 | 10.138 |
| | SD | 0.029 | 0.031 | 0.006 | 0.002 | 0.143 | 0.133 |
| | Percent Change | NS | | 1.27% | | NS | |
| 3 | Mean | 2.383 | 2.417 | 1.698 | 1.679 | 10.027 | 10.074 |
| | SD | 0.015 | 0.033 | 0.012 | 0.028 | 0.071 | 0.023 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.290 | 2.309 | 1.619 | 1.611 | 10.621 | 10.628 |
| | SD | 0.106 | 0.108 | 0.044 | 0.058 | 0.259 | 0.245 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.117 | 1.126 | 1.137 | 1.140 | 10.554 | 10.572 |
| | SD | 0.106 | 0.106 | 0.071 | 0.072 | 0.169 | 0.168 |
| | Percent Change | 0.77% | | 0.23% | | 0.17% | |

Table 2. Continued

Chemical 5

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.288 | 2.307 | 1.694 | 1.714 | 9.827 | 10.048 |
| | SD | 0.008 | 0.009 | 0.009 | 0.018 | 0.057 | 0.128 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.084 | 2.113 | 1.613 | 1.626 | 10.043 | 10.086 |
| | SD | 0.022 | 0.024 | 0.006 | 0.003 | 0.155 | 0.121 |
| | Percent Change | 1.41% | | 0.84% | | NS | |
| 3 | Mean | 2.371 | 2.417 | 1.690 | 1.679 | 9.927 | 10.018 |
| | SD | 0.057 | 0.033 | 0.017 | 0.028 | 0.080 | 0.165 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.311 | 2.373 | 1.628 | 1.625 | 10.429 | 10.541 |
| | SD | 0.132 | 0.164 | 0.030 | 0.028 | 0.671 | 0.655 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.159 | 1.221 | | 1.085 | | 10.797 |
| | SD | 0.071 | 0.074 | | 0.041 | | 0.044 |
| | Percent Change | 5.35% | | 4.70% | | 2.86% | |

Chemical 6

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.274 | 2.277 | 1.671 | 1.664 | 10.127 | 10.124 |
| | SD | 0.016 | 0.011 | 0.009 | 0.004 | 0.019 | 0.053 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.051 | 2.060 | 1.604 | 1.606 | 9.960 | 10.015 |
| | SD | 0.025 | 0.025 | 0.008 | 0.006 | 0.223 | 0.197 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.391 | 2.403 | 1.711 | 1.703 | 9.796 | 10.073 |
| | SD | 0.046 | 0.027 | 0.018 | 0.023 | 0.202 | 0.152 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.323 | 2.344 | 1.646 | 2.448 | 10.637 | 10.629 |
| | SD | 0.020 | 0.042 | 0.046 | 0.014 | 0.431 | 0.452 |
| | Percent Change | NS | | 48.73% | | NS | |
| 5 | Mean | 1.179 | 1.245 | 1.136 | 1.426 | 10.520 | 10.537 |
| | SD | 0.056 | 0.045 | 0.109 | 0.412 | 0.164 | 0.165 |
| | Percent Change | 5.66% | | NS | | 0.16% | |

Table 2. Continued

Chemical 7

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.264 | 2.273 | 1.697 | 1.696 | 9.941 | 9.947 |
| | SD | 0.041 | 0.042 | 0.020 | 0.021 | 0.055 | 0.059 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.120 | 2.129 | 1.617 | 1.626 | 10.358 | 10.264 |
| | SD | 0.067 | 0.067 | 0.008 | 0.011 | 0.358 | 0.314 |
| | Percent Change | 0.43% | | 0.58% | | NS | |
| 3 | Mean | 2.541 | 2.550 | 1.793 | 1.789 | 10.019 | 10.087 |
| | SD | 0.034 | 0.033 | 0.023 | 0.018 | 0.027 | 0.085 |
| | Percent Change | 0.34% | | NS | | NS | |
| 4 | Mean | 2.271 | 2.283 | 1.639 | 1.641 | 10.420 | 10.460 |
| | SD | 0.053 | 0.057 | 0.017 | 0.017 | 0.321 | 0.302 |
| | Percent Change | 0.52% | | NS | | NS | |
| 5 | Mean | 1.182 | 1.197 | 1.136 | 1.138 | 10.558 | 10.784 |
| | SD | 0.062 | 0.064 | 0.109 | 0.109 | 0.077 | 0.096 |
| | Percent Change | 1.24% | | 0.15% | | 2.15% | |

Chemical 8

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.269 | 2.289 | 1.692 | 1.713 | 10.070 | 10.057 |
| | SD | 0.007 | 0.008 | 0.003 | 0.028 | 0.045 | 0.043 |
| | Percent Change | 0.90% | | NS | | NS | |
| 2 | Mean | 2.066 | 2.067 | 1.610 | 1.616 | 10.128 | 10.034 |
| | SD | 0.019 | 0.009 | 0.004 | 0.005 | 0.113 | 0.128 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.581 | 2.619 | 1.808 | 1.804 | 10.046 | 10.149 |
| | SD | 0.064 | 0.050 | 0.034 | 0.028 | 0.070 | 0.256 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.256 | 2.310 | 1.636 | 1.651 | 10.459 | 10.491 |
| | SD | 0.044 | 0.072 | 0.054 | 0.040 | 0.359 | 0.328 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.259 | 0.999 | 1.102 | 1.134 | 10.546 | 10.557 |
| | SD | 0.075 | 0.442 | 0.058 | 0.055 | 0.065 | 0.065 |
| | Percent Change | NS | | 2.97% | | 0.10% | |

Table 2. Continued

Chemical 9

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.255 | 2.264 | 1.691 | 1.691 | 10.047 | 10.064 |
| | SD | 0.020 | 0.019 | 0.010 | 0.008 | 0.060 | 0.185 |
| | Percent Change | 0.39% | | NS | | NS | |
| 2 | Mean | 2.058 | 2.066 | 1.595 | 1.610 | 10.033 | 10.073 |
| | SD | 0.010 | 0.019 | 0.031 | 0.004 | 0.103 | 0.156 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.598 | 2.647 | 1.823 | 1.826 | 10.134 | 10.064 |
| | SD | 0.022 | 0.047 | 0.020 | 0.031 | 0.096 | 0.062 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.286 | 2.245 | 1.660 | 1.659 | 10.389 | 10.266 |
| | SD | 0.071 | 0.040 | 0.015 | 0.005 | 0.270 | 0.164 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.256 | 1.265 | 1.102 | 1.105 | 10.611 | 10.628 |
| | SD | 0.063 | 0.063 | 0.058 | 0.056 | 0.052 | 0.057 |
| | Percent Change | 0.75% | | NS | | NS | |

Chemical 10

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.282 | 2.304 | 1.701 | 1.708 | 10.006 | 9.959 |
| | SD | 0.035 | 0.034 | 0.013 | 0.015 | 0.028 | 0.075 |
| | Percent Change | 0.96% | | NS | | NS | |
| 2 | Mean | 2.064 | 2.082 | 1.609 | 1.619 | 9.966 | 10.016 |
| | SD | 0.016 | 0.021 | 0.004 | 0.000 | 0.012 | 0.161 |
| | Percent Change | 0.86% | | 0.66% | | NS | |
| 3 | Mean | 2.520 | 2.571 | 1.779 | 1.776 | 10.045 | 10.314 |
| | SD | 0.023 | 0.058 | 0.020 | 0.023 | 0.040 | 0.387 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.185 | 2.307 | 1.620 | 1.636 | 10.427 | 10.464 |
| | SD | 0.041 | 0.075 | 0.020 | 0.047 | 0.194 | 0.092 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.236 | 1.291 | 1.111 | 1.132 | 10.429 | 10.551 |
| | SD | 0.103 | 0.099 | 0.059 | 0.059 | 0.063 | 0.131 |
| | Percent Change | 4.46% | | 1.89% | | 1.50% | |

Table 2. Continued

Chemical 11

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.270 | 2.286 | 1.698 | 1.707 | 9.920 | 10.050 |
| | SD | 0.041 | 0.040 | 0.009 | 0.003 | 0.042 | 0.115 |
| | Percent Change | 0.71% | | NS | | NS | |
| 2 | Mean | 2.049 | 2.061 | 1.608 | 1.616 | 10.013 | 9.902 |
| | SD | 0.025 | 0.025 | 0.001 | 0.002 | 0.003 | 0.106 |
| | Percent Change | NS | | 0.55% | | NS | |
| 3 | Mean | 2.446 | 2.482 | 1.736 | 1.733 | 10.093 | 10.191 |
| | SD | 0.113 | 0.107 | 0.057 | 0.060 | 0.345 | 0.285 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.272 | 2.297 | 1.668 | 1.677 | 10.322 | 10.331 |
| | SD | 0.063 | 0.063 | 0.010 | 0.014 | 0.248 | 0.271 |
| | Percent Change | 1.09% | | NS | | NS | |
| 5 | Mean | 1.161 | 1.190 | 1.137 | 1.152 | 10.141 | 10.231 |
| | SD | 0.115 | 0.112 | 0.100 | 0.100 | 0.455 | 0.440 |
| | Percent Change | 2.47% | | 1.32% | | 0.88% | |

Chemical 12

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.256 | 2.694 | 1.690 | 1.852 | 9.991 | 12.730 |
| | SD | 0.053 | 0.024 | 0.019 | 0.015 | 0.142 | 0.367 |
| | Percent Change | 19.43% | | 9.61% | | 27.42% | |
| 2 | Mean | 2.046 | 2.492 | 1.614 | 1.808 | 9.878 | 11.497 |
| | SD | 0.036 | 0.029 | 0.008 | 0.006 | 0.207 | 0.061 |
| | Percent Change | 21.76% | | 12.02% | | 16.38% | |
| 3 | Mean | 2.461 | 2.957 | 1.764 | 1.947 | 9.928 | 11.439 |
| | SD | 0.108 | 0.129 | 0.051 | 0.055 | 0.093 | 0.060 |
| | Percent Change | 20.15% | | 10.37% | | 15.22% | |
| 4 | Mean | 2.235 | 3.000 | 1.628 | 1.921 | 10.371 | 12.293 |
| | SD | 0.049 | 0.052 | 0.020 | 0.048 | 0.109 | 0.054 |
| | Percent Change | 34.20% | | 17.97% | | 18.53% | |
| 5 | Mean | 1.187 | 1.747 | 1.151 | 1.315 | 10.457 | 12.129 |
| | SD | 0.064 | 0.106 | 0.180 | 0.107 | 0.422 | 0.505 |
| | Percent Change | 47.13% | | NS | | 16.00% | |

Table 2. Continued

Chemical 13

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.248 | 2.259 | 1.668 | 1.662 | 9.978 | 10.098 |
| | SD | 0.016 | 0.016 | 0.017 | 0.020 | 0.019 | 0.178 |
| | Percent Change | 0.50% | | NS | | NS | |
| 2 | Mean | 2.086 | 2.101 | 1.612 | 1.600 | 10.198 | 10.081 |
| | SD | 0.015 | 0.015 | 0.007 | 0.009 | 0.184 | 0.170 |
| | Percent Change | 0.72% | | -0.77% | | NS | |
| 3 | Mean | 2.438 | 2.444 | 1.744 | 1.723 | 9.741 | 9.960 |
| | SD | 0.092 | 0.092 | 0.045 | 0.050 | 0.230 | 0.026 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.140 | 2.196 | 1.598 | 1.588 | 10.338 | 10.063 |
| | SD | 0.036 | 0.041 | 0.013 | 0.020 | 0.068 | 0.055 |
| | Percent Change | NS | | NS | | -2.66% | |
| 5 | Mean | 1.190 | 1.199 | 1.147 | 1.148 | 10.204 | 10.272 |
| | SD | 0.099 | 0.099 | 0.090 | 0.090 | 0.238 | 0.348 |
| | Percent Change | NS | | 0.08% | | NS | |

Chemical 14

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.264 | 2.278 | 1.685 | 1.694 | 9.957 | 10.022 |
| | SD | 0.016 | 0.015 | 0.022 | 0.023 | 0.169 | 0.156 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.042 | 2.047 | 1.602 | 1.604 | 9.872 | 9.984 |
| | SD | 0.018 | 0.017 | 0.017 | 0.016 | 0.300 | 0.195 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.485 | 2.519 | 1.763 | 1.733 | 10.015 | 10.215 |
| | SD | 0.094 | 0.090 | 0.034 | 0.021 | 0.077 | 0.174 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.301 | 2.271 | 1.654 | 1.647 | 10.107 | 10.175 |
| | SD | 0.076 | 0.024 | 0.011 | 0.021 | 0.244 | 0.281 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.248 | 1.273 | 1.149 | 1.168 | 10.457 | 10.544 |
| | SD | 0.103 | 0.106 | 0.084 | 0.082 | 0.239 | 0.233 |
| | Percent Change | 2.06% | | 1.62% | | 0.83% | |

Table 2. Continued

Chemical 15

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.279 | 2.731 | 1.683 | 1.834 | 10.168 | 11.281 |
| | SD | 0.037 | 0.040 | 0.031 | 0.037 | 0.108 | 0.126 |
| | Percent Change | 19.83% | | 8.99% | | 10.95% | |
| 2 | Mean | 2.064 | 2.282 | 1.607 | 1.699 | 10.164 | 10.706 |
| | SD | 0.038 | 0.050 | 0.015 | 0.024 | 0.028 | 0.227 |
| | Percent Change | 10.57% | | 5.75% | | 5.33% | |
| 3 | Mean | 2.557 | 3.285 | 1.784 | 1.882 | 10.227 | 10.856 |
| | SD | 0.044 | 0.507 | 0.008 | 0.016 | 0.314 | 0.393 |
| | Percent Change | NS | | 5.54% | | NS | |
| 4 | Mean | 2.271 | 2.554 | 1.654 | 1.685 | 10.459 | 11.093 |
| | SD | 0.063 | 0.050 | 0.026 | 0.044 | 0.204 | 0.330 |
| | Percent Change | 12.46% | | NS | | 6.06% | |
| 5 | Mean | 1.227 | 1.695 | 1.136 | 1.278 | 10.423 | 11.879 |
| | SD | 0.059 | 0.069 | 0.109 | 0.119 | 0.578 | 0.082 |
| | Percent Change | 38.17% | | 12.48% | | 13.97% | |

Chemical 16

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.265 | 2.284 | 1.679 | 1.703 | 10.143 | 9.908 |
| | SD | 0.022 | 0.020 | 0.004 | 0.018 | 0.109 | 0.265 |
| | Percent Change | 0.86% | | NS | | NS | |
| 2 | Mean | 2.057 | 2.061 | 1.608 | 1.610 | 10.077 | 10.004 |
| | SD | 0.009 | 0.009 | 0.006 | 0.001 | 0.090 | 0.105 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.476 | 2.492 | 1.762 | 1.755 | 10.185 | 10.214 |
| | SD | 0.071 | 0.070 | 0.026 | 0.026 | 0.112 | 0.130 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.270 | 2.354 | 1.647 | 1.654 | 10.495 | 10.393 |
| | SD | 0.039 | 0.108 | 0.023 | 0.029 | 0.502 | 0.280 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.253 | 1.284 | 1.187 | 1.216 | 10.345 | 10.512 |
| | SD | 0.060 | 0.063 | 0.085 | 0.084 | 0.110 | 0.351 |
| | Percent Change | 2.53% | | 2.39% | | NS | |

Table 2. Continued

Chemical 17

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.272 | 3.388 | 1.683 | 1.969 | 9.997 | 12.338 |
| | SD | 0.047 | 0.121 | 0.026 | 0.043 | 0.073 | 0.300 |
| | Percent Change | 49.10% | | 16.97% | | 23.42% | |
| 2 | Mean | 2.042 | 2.635 | 1.608 | 1.950 | 9.892 | 11.183 |
| | SD | 0.011 | 0.019 | 0.004 | 0.027 | 0.004 | 0.051 |
| | Percent Change | 29.07% | | 21.22% | | 13.06% | |
| 3 | Mean | 2.499 | 2.680 | 1.760 | 1.767 | 10.267 | 10.692 |
| | SD | 0.049 | 0.067 | 0.015 | 0.023 | 0.338 | 0.366 |
| | Percent Change | 7.22% | | NS | | NS | |
| 4 | Mean | 2.264 | 2.657 | 1.642 | 1.632 | 10.156 | 11.583 |
| | SD | 0.211 | 0.104 | 0.039 | 0.038 | 0.542 | 0.197 |
| | Percent Change | 17.37% | | NS | | 14.05% | |
| 5 | Mean | 1.253 | 2.385 | 1.118 | 1.213 | 10.513 | 13.497 |
| | SD | 0.073 | 0.220 | 0.069 | 0.135 | 0.051 | 0.317 |
| | Percent Change | 90.38% | | NS | | 28.39% | |

Chemical 18

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.284 | 2.313 | 1.705 | 1.711 | 10.179 | 10.070 |
| | SD | 0.036 | 0.018 | 0.014 | 0.014 | 0.073 | 0.102 |
| | Percent Change | NS | | NS | | -1.08% | |
| 2 | Mean | 2.075 | 2.795 | 1.616 | 2.037 | 10.035 | 11.346 |
| | SD | 0.023 | 0.025 | 0.004 | 0.065 | 0.083 | 0.104 |
| | Percent Change | 34.67% | | 26.10% | | 13.06% | |
| 3 | Mean | 2.471 | 2.983 | 1.761 | 1.780 | 10.511 | 11.465 |
| | SD | 0.019 | 0.046 | 0.001 | 0.065 | 0.432 | 0.568 |
| | Percent Change | 20.71% | | NS | | 9.08% | |
| 4 | Mean | 2.237 | 2.750 | 1.641 | 1.677 | 10.003 | 11.735 |
| | SD | 0.143 | 0.141 | 0.019 | 0.021 | 0.239 | 0.355 |
| | Percent Change | 22.91% | | NS | | 17.31% | |
| 5 | Mean | 1.239 | 1.349 | 1.130 | 1.146 | 10.354 | 10.746 |
| | SD | 0.064 | 0.056 | 0.106 | 0.111 | 0.136 | 0.328 |
| | Percent Change | 8.88% | | NS | | 3.78% | |

Table 2. Continued

Chemical 19

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.288 | 3.041 | 1.709 | 1.874 | 10.061 | 12.093 |
| | SD | 0.006 | 0.094 | 0.003 | 0.035 | 0.068 | 0.174 |
| | Percent Change | 32.90% | | 9.65% | | 20.20% | |
| 2 | Mean | 2.070 | 2.308 | 1.621 | 1.690 | 9.945 | 10.774 |
| | SD | 0.042 | 0.056 | 0.006 | 0.024 | 0.218 | 0.219 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.488 | 2.551 | 1.749 | 1.730 | 9.941 | 10.406 |
| | SD | 0.088 | 0.057 | 0.031 | 0.018 | 0.170 | 0.405 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.245 | 2.366 | 1.630 | 1.646 | 10.284 | 10.733 |
| | SD | 0.032 | 0.053 | 0.029 | 0.027 | 0.166 | 0.033 |
| | Percent Change | 5.42% | | NS | | 4.37% | |
| 5 | Mean | 1.307 | 1.402 | 1.130 | 1.163 | 10.851 | 11.476 |
| | SD | 0.050 | 0.078 | 0.066 | 0.022 | 0.322 | 0.167 |
| | Percent Change | NS | | NS | | NS | |

Chemical 20

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.260 | 2.322 | 1.673 | 1.691 | 10.076 | 10.078 |
| | SD | 0.040 | 0.042 | 0.031 | 0.020 | 0.148 | 0.116 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.050 | 2.144 | 1.612 | 1.649 | 10.194 | 10.086 |
| | SD | 0.044 | 0.045 | 0.011 | 0.005 | 0.208 | 0.327 |
| | Percent Change | 4.59% | | 2.28% | | NS | |
| 3 | Mean | 2.509 | 2.632 | 1.758 | 1.762 | 10.113 | 10.471 |
| | SD | 0.037 | 0.046 | 0.009 | 0.030 | 0.015 | 0.282 |
| | Percent Change | 4.88% | | NS | | NS | |
| 4 | Mean | 2.263 | 2.329 | 1.653 | 1.654 | 10.040 | 10.425 |
| | SD | 0.071 | 0.070 | 0.024 | 0.024 | 0.104 | 0.157 |
| | Percent Change | 2.92% | | NS | | NS | |
| 5 | Mean | 1.196 | 1.210 | 1.145 | 1.240 | 10.283 | 10.553 |
| | SD | 0.029 | 0.030 | 0.039 | 0.035 | 0.057 | 0.013 |
| | Percent Change | 1.18% | | 8.30% | | 2.63% | |

Table 2. Continued

Chemical 21

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.292 | 2.372 | 1.701 | 1.741 | 10.034 | 10.212 |
| | SD | 0.033 | 0.008 | 0.026 | 0.024 | 0.012 | 0.074 |
| | Percent Change | 3.48% | | NS | | NS | |
| 2 | Mean | 2.144 | 2.199 | 1.614 | 1.629 | 10.113 | 10.599 |
| | SD | 0.090 | 0.095 | 0.004 | 0.008 | 0.138 | 0.422 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.467 | 2.702 | 1.744 | 1.867 | 10.023 | 10.210 |
| | SD | 0.056 | 0.042 | 0.030 | 0.022 | 0.014 | 0.153 |
| | Percent Change | 9.52% | | 7.08% | | NS | |
| 4 | Mean | 2.203 | 2.315 | 1.648 | 1.712 | 9.955 | 10.449 |
| | SD | 0.058 | 0.062 | 0.043 | 0.037 | 0.413 | 0.267 |
| | Percent Change | 5.10% | | 3.88% | | NS | |
| 5 | Mean | 1.140 | 1.265 | 1.126 | 1.204 | 10.174 | 10.468 |
| | SD | 0.086 | 0.068 | 0.097 | 0.093 | 0.211 | 0.210 |
| | Percent Change | 10.96% | | 6.90% | | 2.88% | |

Chemical 22

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.248 | 4.378 | 1.693 | 1.937 | 9.979 | 14.639 |
| | SD | 0.006 | 0.072 | 0.014 | 0.080 | 0.056 | 0.027 |
| | Percent Change | 94.78% | | 14.47% | | 46.69% | |
| 2 | Mean | 2.083 | 4.348 | 1.619 | 2.154 | 10.135 | 15.811 |
| | SD | 0.021 | 0.052 | 0.001 | 0.181 | 0.023 | 0.158 |
| | Percent Change | 108.74% | | 33.05% | | 56.01% | |
| 3 | Mean | 2.398 | 4.279 | 1.738 | 1.690 | 9.720 | 14.160 |
| | SD | 0.063 | 0.661 | 0.016 | 0.026 | 0.053 | 0.633 |
| | Percent Change | 78.40% | | NS | | 45.67% | |
| 4 | Mean | 2.277 | 4.467 | 1.663 | 2.009 | 10.235 | 14.089 |
| | SD | 0.083 | 0.151 | 0.008 | 0.067 | 0.056 | 0.214 |
| | Percent Change | 96.14% | | 20.84% | | 37.65% | |
| 5 | Mean | 1.174 | 3.268 | 1.089 | 1.383 | 10.316 | 17.295 |
| | SD | 0.082 | 0.162 | 0.064 | 0.145 | 0.434 | 0.183 |
| | Percent Change | 178.37% | | NS | | 67.66% | |

Table 2. Continued

Chemical 23

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.256 | 2.288 | 1.677 | 1.688 | 10.069 | 9.969 |
| | SD | 0.027 | 0.025 | 0.011 | 0.006 | 0.072 | 0.099 |
| | Percent Change | 1.40% | | NS | | NS | |
| 2 | Mean | 2.109 | 2.181 | 1.622 | 1.603 | 10.180 | 10.218 |
| | SD | 0.022 | 0.072 | 0.007 | 0.012 | 0.081 | 0.145 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.489 | 2.512 | 1.753 | 1.780 | 10.226 | 10.203 |
| | SD | 0.051 | 0.056 | 0.030 | 0.066 | 0.009 | 0.036 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.203 | 2.266 | 1.610 | 1.595 | 10.056 | 10.350 |
| | SD | 0.064 | 0.061 | 0.024 | 0.022 | 0.246 | 0.103 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.179 | 1.246 | 1.110 | 1.143 | 10.144 | 10.096 |
| | SD | 0.123 | 0.125 | 0.095 | 0.096 | 0.374 | 0.377 |
| | Percent Change | 5.62% | | 3.00% | | -0.47% | |

Chemical 24

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.272 | 3.286 | 1.675 | 1.759 | 10.241 | 13.823 |
| | SD | 0.022 | 0.127 | 0.016 | 0.035 | 0.002 | 0.132 |
| | Percent Change | 44.66% | | NS | | 34.98% | |
| 2 | Mean | 2.072 | 3.539 | 1.618 | 1.827 | 9.952 | 14.606 |
| | SD | 0.053 | 0.274 | 0.006 | 0.006 | 0.300 | 0.145 |
| | Percent Change | 70.76% | | 12.93% | | 46.76% | |
| 3 | Mean | 2.568 | 3.594 | 1.785 | 1.768 | 10.130 | 13.673 |
| | SD | 0.057 | 0.121 | 0.007 | 0.107 | 0.268 | 0.020 |
| | Percent Change | 39.95% | | NS | | 34.97% | |
| 4 | Mean | 2.260 | 3.093 | 1.648 | 1.767 | 10.109 | 14.219 |
| | SD | 0.068 | 0.246 | 0.012 | 0.025 | 0.043 | 0.566 |
| | Percent Change | 36.87% | | 7.21% | | 40.65% | |
| 5 | Mean | 1.227 | 3.046 | 1.140 | 1.044 | 10.195 | 19.045 |
| | SD | 0.111 | 0.590 | 0.038 | 0.218 | 0.613 | 0.502 |
| | Percent Change | 148.23% | | NS | | 86.80% | |

Table 2. Continued

Chemical 25

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.281 | 2.721 | 1.687 | 1.861 | 9.784 | 11.582 |
| | SD | 0.017 | 0.125 | 0.020 | 0.075 | 0.323 | 0.182 |
| | Percent Change | 19.31% | | NS | | 18.37% | |
| 2 | Mean | 2.193 | 2.302 | 1.628 | 1.680 | 10.006 | 10.540 |
| | SD | 0.211 | 0.247 | 0.025 | 0.049 | 0.039 | 0.326 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.486 | 2.603 | 1.763 | 1.705 | 10.122 | 10.820 |
| | SD | 0.101 | 0.005 | 0.064 | 0.016 | 0.048 | 0.643 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.324 | 2.398 | 1.675 | 1.696 | 10.388 | 10.488 |
| | SD | 0.075 | 0.087 | 0.016 | 0.028 | 0.152 | 0.393 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.268 | 1.584 | 1.129 | 1.276 | 10.823 | 11.918 |
| | SD | 0.054 | 0.091 | 0.044 | 0.086 | 0.316 | 0.186 |
| | Percent Change | 24.97% | | NS | | 10.11% | |

Chemical 26

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.246 | 2.259 | 1.690 | 1.689 | 10.078 | 10.032 |
| | SD | 0.019 | 0.019 | 0.017 | 0.014 | 0.032 | 0.013 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.066 | 2.071 | 1.616 | 1.613 | 10.069 | 10.054 |
| | SD | 0.024 | 0.021 | 0.006 | 0.010 | 0.015 | 0.037 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.385 | 2.396 | 1.701 | 1.701 | 9.858 | 9.896 |
| | SD | 0.032 | 0.031 | 0.042 | 0.036 | 0.120 | 0.102 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.162 | 2.172 | 1.648 | 1.647 | 10.083 | 10.167 |
| | SD | 0.046 | 0.043 | 0.009 | 0.011 | 0.136 | 0.031 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.208 | 1.320 | 1.150 | 1.153 | 10.279 | 10.250 |
| | SD | 0.061 | 0.124 | 0.066 | 0.061 | 0.220 | 0.233 |
| | Percent Change | NS | | NS | | NS | |

Table 2. Continued

Chemical 27

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.254 | 2.282 | 1.688 | 1.704 | 10.030 | 10.095 |
| | SD | 0.052 | 0.042 | 0.029 | 0.025 | 0.001 | 0.042 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.086 | 2.381 | 1.616 | 1.666 | 10.078 | 10.714 |
| | SD | 0.012 | 0.045 | 0.006 | 0.021 | 0.022 | 0.434 |
| | Percent Change | 14.10% | | NS | | 6.31% | |
| 3 | Mean | 2.457 | 2.509 | 1.719 | 1.751 | 10.250 | 10.422 |
| | SD | 0.060 | 0.065 | 0.024 | 0.022 | 0.283 | 0.155 |
| | Percent Change | 2.09% | | NS | | NS | |
| 4 | Mean | 2.310 | 2.360 | 1.651 | 1.660 | 10.314 | 10.772 |
| | SD | 0.120 | 0.119 | 0.025 | 0.023 | 0.216 | 0.391 |
| | Percent Change | 2.18% | | NS | | NS | |
| 5 | Mean | 1.288 | 1.425 | 1.143 | 1.161 | 10.442 | 11.039 |
| | SD | 0.153 | 0.162 | 0.078 | 0.078 | 0.234 | 0.302 |
| | Percent Change | 10.59% | | 1.58% | | 5.72% | |

Chemical 28

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.272 | 2.307 | 1.697 | 1.697 | 10.117 | 10.116 |
| | SD | 0.026 | 0.024 | 0.024 | 0.027 | 0.083 | 0.139 |
| | Percent Change | 1.54% | | NS | | NS | |
| 2 | Mean | 2.080 | 2.150 | 1.617 | 1.638 | 10.182 | 11.386 |
| | SD | 0.045 | 0.008 | 0.002 | 0.008 | 0.171 | 0.252 |
| | Percent Change | 3.35% | | 1.28% | | 11.83% | |
| 3 | Mean | 2.418 | 2.578 | 1.713 | 1.718 | 10.205 | 10.140 |
| | SD | 0.038 | 0.157 | 0.020 | 0.010 | 0.060 | 0.003 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.367 | 2.445 | 1.677 | 1.687 | 10.249 | 10.501 |
| | SD | 0.120 | 0.149 | 0.017 | 0.019 | 0.181 | 0.228 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.214 | 1.299 | 1.142 | 1.151 | 10.476 | 10.698 |
| | SD | 0.090 | 0.092 | 0.097 | 0.097 | 0.224 | 0.213 |
| | Percent Change | 7.06% | | 0.76% | | 2.13% | |

Table 2. Continued

Chemical 29

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.238 | 2.347 | 1.669 | 1.699 | 10.147 | 10.326 |
| | SD | 0.046 | 0.090 | 0.004 | 0.003 | 0.205 | 0.163 |
| | Percent Change | NS | | 1.76% | | NS | |
| 2 | Mean | 2.125 | 2.279 | 1.612 | 1.635 | 10.404 | 10.670 |
| | SD | 0.072 | 0.286 | 0.007 | 0.042 | 0.180 | 0.218 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.460 | 2.573 | 1.740 | 1.770 | 10.072 | 10.372 |
| | SD | 0.064 | 0.054 | 0.051 | 0.054 | 0.047 | 0.106 |
| | Percent Change | 4.60% | | 1.73% | | 2.98% | |
| 4 | Mean | 2.232 | 2.344 | 1.656 | 1.671 | 9.986 | 10.587 |
| | SD | 0.030 | 0.043 | 0.024 | 0.029 | 0.072 | 0.104 |
| | Percent Change | 5.00% | | NS | | 6.01% | |
| 5 | Mean | 1.199 | 1.574 | 1.141 | 1.204 | 10.293 | 11.391 |
| | SD | 0.042 | 0.070 | 0.066 | 0.062 | 0.232 | 0.763 |
| | Percent Change | 31.34% | | 5.52% | | 12.48% | |

Chemical 30

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.279 | 4.262 | 1.701 | 2.202 | 10.081 | 15.305 |
| | SD | 0.028 | 0.277 | 0.022 | 0.100 | 0.029 | 0.188 |
| | Percent Change | 87.06% | | 29.47% | | 51.81% | |
| 2 | Mean | 2.052 | 2.729 | 1.617 | 1.783 | 10.155 | 12.515 |
| | SD | 0.019 | 0.014 | 0.004 | 0.057 | 0.178 | 0.183 |
| | Percent Change | 32.99% | | 10.27% | | 23.24% | |
| 3 | Mean | 2.432 | 3.360 | 1.714 | 1.989 | 9.952 | 12.177 |
| | SD | 0.060 | 0.128 | 0.040 | 0.066 | 0.293 | 0.030 |
| | Percent Change | 38.14% | | 16.03% | | 22.35% | |
| 4 | Mean | 2.247 | 3.428 | 1.634 | 1.962 | 10.341 | 11.689 |
| | SD | 0.057 | 0.100 | 0.030 | 0.100 | 0.309 | 0.134 |
| | Percent Change | 52.53% | | 20.05% | | 13.03% | |
| 5 | Mean | 1.198 | 2.114 | 1.150 | 1.440 | 10.279 | 12.385 |
| | SD | 0.044 | 0.037 | 0.066 | 0.060 | 0.220 | 0.104 |
| | Percent Change | 76.40% | | NS | | 20.48% | |

Table 2. Continued

Chemical 31

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.255 | 2.927 | 1.691 | 1.939 | 10.019 | 11.758 |
| | SD | 0.044 | 0.051 | 0.026 | 0.010 | 0.013 | 0.133 |
| | Percent Change | 29.80% | | 14.66% | | 17.36% | |
| 2 | Mean | 2.058 | 2.847 | 1.567 | 1.888 | 10.199 | 11.758 |
| | SD | 0.020 | 0.028 | 0.022 | 0.025 | 0.153 | 0.133 |
| | Percent Change | 38.35% | | 20.50% | | 15.29% | |
| 3 | Mean | 2.423 | 3.013 | 1.730 | 1.968 | 9.990 | 11.602 |
| | SD | 0.045 | 0.047 | 0.044 | 0.064 | 0.005 | 0.153 |
| | Percent Change | 24.35% | | NS | | 16.13% | |
| 4 | Mean | 2.315 | 2.878 | 1.653 | 1.904 | 10.555 | 11.919 |
| | SD | 0.060 | 0.083 | 0.002 | 0.033 | 0.242 | 0.319 |
| | Percent Change | 24.32% | | 15.13% | | 12.92% | |
| 5 | Mean | 1.153 | 1.906 | 1.044 | 1.492 | 10.428 | 13.167 |
| | SD | 0.018 | 0.114 | 0.054 | 0.020 | 0.251 | 0.223 |
| | Percent Change | 65.30% | | 42.98% | | 26.26% | |

Chemical 32

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.262 | 2.283 | 1.671 | 1.691 | 10.083 | 10.096 |
| | SD | 0.038 | 0.038 | 0.007 | 0.007 | 0.064 | 0.124 |
| | Percent Change | 0.94% | | NS | | NS | |
| 2 | Mean | 2.082 | 2.094 | 1.589 | 1.570 | 10.306 | 10.096 |
| | SD | 0.020 | 0.019 | 0.004 | 0.001 | 0.008 | 0.124 |
| | Percent Change | NS | | -1.20% | | NS | |
| 3 | Mean | 2.401 | 2.417 | 1.716 | 1.722 | 10.010 | 10.128 |
| | SD | 0.027 | 0.026 | 0.029 | 0.017 | 0.100 | 0.036 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.285 | 2.290 | 1.629 | 1.630 | 10.254 | 10.715 |
| | SD | 0.053 | 0.057 | 0.015 | 0.012 | 0.286 | 0.661 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.273 | 1.300 | 1.144 | 1.165 | 10.661 | 10.704 |
| | SD | 0.073 | 0.078 | 0.089 | 0.088 | 0.290 | 0.237 |
| | Percent Change | 2.15% | | 1.84% | | NS | |

Table 2. Continued

Chemical 33

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.289 | 3.059 | 1.681 | 1.939 | 10.187 | 12.452 |
| | SD | 0.035 | 0.029 | 0.018 | 0.034 | 0.087 | 0.318 |
| | Percent Change | 33.62% | | 15.35% | | 22.24% | |
| 2 | Mean | 2.046 | 2.742 | 1.590 | 1.913 | 10.389 | 12.452 |
| | SD | 0.016 | 0.030 | 0.006 | 0.034 | 0.305 | 0.318 |
| | Percent Change | 34.02% | | 20.29% | | 19.86% | |
| 3 | Mean | 2.508 | 2.785 | 1.716 | 1.866 | 10.817 | 12.289 |
| | SD | 0.156 | 0.195 | 0.047 | 0.104 | 0.505 | 0.594 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.220 | 2.643 | 1.617 | 1.923 | 10.320 | 11.742 |
| | SD | 0.083 | 0.094 | 0.022 | 0.018 | 0.213 | 0.383 |
| | Percent Change | 19.05% | | 18.87% | | 13.79% | |
| 5 | Mean | 1.188 | 2.660 | 1.064 | 1.611 | 10.388 | 15.912 |
| | SD | 0.029 | 0.552 | 0.032 | 0.058 | 0.352 | 0.133 |
| | Percent Change | 123.95% | | 51.40% | | 53.17% | |

Chemical 34

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.275 | 3.004 | 1.682 | 1.796 | 9.976 | 12.584 |
| | SD | 0.045 | 0.046 | 0.021 | 0.030 | 0.024 | 0.305 |
| | Percent Change | 32.05% | | 6.80% | | 26.15% | |
| 2 | Mean | 2.096 | 3.223 | 1.627 | 2.008 | 10.229 | 12.904 |
| | SD | 0.019 | 0.108 | 0.010 | 0.048 | 0.038 | 0.315 |
| | Percent Change | 53.75% | | 23.44% | | 26.15% | |
| 3 | Mean | 2.478 | 3.415 | 1.737 | 1.709 | 10.128 | 13.068 |
| | SD | 0.088 | 0.071 | 0.040 | 0.092 | 0.030 | 0.219 |
| | Percent Change | 37.78% | | NS | | 29.03% | |
| 4 | Mean | 2.229 | 3.289 | 1.664 | 1.887 | 10.101 | 12.668 |
| | SD | 0.048 | 0.366 | 0.031 | 0.115 | 0.246 | 0.095 |
| | Percent Change | 47.57% | | 13.41% | | 25.42% | |
| 5 | Mean | 1.120 | 3.417 | 1.057 | 1.096 | 11.029 | 20.371 |
| | SD | 0.014 | 0.089 | 0.057 | 0.052 | 1.195 | 1.971 |
| | Percent Change | 205.11% | | NS | | 84.71% | |

Table 2. Continued

Chemical 35

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.274 | 3.040 | 1.672 | 1.879 | 10.183 | 13.354 |
| | SD | 0.020 | 0.037 | 0.010 | 0.029 | 0.038 | 0.183 |
| | Percent Change | 33.67% | | 12.38% | | 31.14% | |
| 2 | Mean | 2.073 | 3.107 | 1.625 | 1.867 | 10.116 | 14.328 |
| | SD | 0.004 | 0.035 | 0.008 | 0.006 | 0.032 | 0.249 |
| | Percent Change | 49.86% | | 14.89% | | 41.63% | |
| 3 | Mean | 2.494 | 3.657 | 1.740 | 1.801 | 10.277 | 14.158 |
| | SD | 0.107 | 0.358 | 0.057 | 0.056 | 0.353 | 0.795 |
| | Percent Change | 46.62% | | NS | | NS | |
| 4 | Mean | 2.253 | 3.135 | 1.649 | 1.850 | 10.675 | 13.344 |
| | SD | 0.067 | 0.093 | 0.015 | 0.012 | 0.238 | 0.390 |
| | Percent Change | 39.15% | | 12.19% | | 25.01% | |
| 5 | Mean | 1.225 | 3.470 | 1.113 | 1.271 | 10.066 | 21.215 |
| | SD | 0.007 | 0.209 | 0.062 | 0.061 | 0.599 | 0.238 |
| | Percent Change | 183.34% | | NS | | 110.76% | |

Chemical 36

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.275 | 2.375 | 1.698 | 1.736 | 10.033 | 10.178 |
| | SD | 0.027 | 0.048 | 0.003 | 0.009 | 0.043 | 0.059 |
| | Percent Change | 4.42% | | 2.24% | | 1.44% | |
| 2 | Mean | 2.115 | 2.142 | 1.631 | 1.637 | 10.193 | 10.296 |
| | SD | 0.030 | 0.031 | 0.015 | 0.028 | 0.080 | 0.031 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.467 | 2.552 | 1.746 | 1.759 | 9.990 | 10.197 |
| | SD | 0.042 | 0.047 | 0.029 | 0.022 | 0.377 | 0.084 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.226 | 2.295 | 1.618 | 1.627 | 10.069 | 10.304 |
| | SD | 0.049 | 0.033 | 0.048 | 0.047 | 0.138 | 0.123 |
| | Percent Change | 3.12% | | NS | | 2.34% | |
| 5 | Mean | 1.171 | 1.281 | 1.114 | 1.176 | 10.125 | 10.507 |
| | SD | 0.133 | 0.144 | 0.066 | 0.062 | 0.738 | 0.559 |
| | Percent Change | 9.43% | | 5.51% | | 6.22% | |

Table 2. Continued

Chemical 37

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.265 | 2.267 | 1.677 | 1.645 | 10.120 | 10.152 |
| | SD | 0.022 | 0.023 | 0.022 | 0.003 | 0.056 | 0.118 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.091 | 2.092 | 1.619 | 1.584 | 10.084 | 10.037 |
| | SD | 0.020 | 0.022 | 0.015 | 0.017 | 0.050 | 0.105 |
| | Percent Change | NS | | -2.17% | | NS | |
| 3 | Mean | 2.549 | 2.568 | 1.749 | 1.730 | 10.100 | 10.279 |
| | SD | 0.084 | 0.098 | 0.020 | 0.029 | 0.128 | 0.245 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.291 | 2.292 | 1.657 | 1.633 | 10.635 | 10.370 |
| | SD | 0.086 | 0.085 | 0.013 | 0.014 | 0.416 | 0.334 |
| | Percent Change | NS | | -1.41% | | NS | |
| 5 | Mean | 1.178 | 1.182 | 1.113 | 1.036 | 10.305 | 10.389 |
| | SD | 0.136 | 0.137 | 0.060 | 0.073 | 0.563 | 0.567 |
| | Percent Change | NS | | -6.89% | | NS | |

Chemical 38

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.259 | 2.706 | 1.671 | 1.777 | 10.009 | 12.340 |
| | SD | 0.021 | 0.027 | 0.017 | 0.080 | 0.067 | 0.160 |
| | Percent Change | 19.75% | | NS | | 23.29% | |
| 2 | Mean | 2.086 | 2.765 | 1.613 | 1.688 | 10.103 | 12.703 |
| | SD | 0.029 | 0.007 | 0.016 | 0.070 | 0.176 | 0.033 |
| | Percent Change | 32.57% | | NS | | 25.74% | |
| 3 | Mean | 2.469 | 2.772 | 1.752 | 1.672 | 9.972 | 10.683 |
| | SD | 0.064 | 0.099 | 0.051 | 0.051 | 0.195 | 0.341 |
| | Percent Change | 12.25% | | -4.55% | | 7.13% | |
| 4 | Mean | 2.234 | 2.742 | 1.663 | 1.747 | 10.045 | 11.062 |
| | SD | 0.045 | 0.062 | 0.022 | 0.049 | 0.155 | 0.342 |
| | Percent Change | 22.72% | | NS | | 10.12% | |
| 5 | Mean | 1.277 | 2.120 | 1.155 | 1.315 | 10.453 | 13.820 |
| | SD | 0.120 | 0.155 | 0.086 | 0.085 | 0.224 | 0.462 |
| | Percent Change | 66.03% | | 13.85% | | 32.21% | |

Table 2. Continued

Chemical 39

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.275 | 2.392 | 1.680 | 1.709 | 10.088 | 11.077 |
| | SD | 0.025 | 0.032 | 0.028 | 0.014 | 0.066 | 0.165 |
| | Percent Change | 5.15% | | 1.70% | | 9.80% | |
| 2 | Mean | 2.069 | 3.121 | 1.614 | 1.928 | 10.119 | 12.913 |
| | SD | 0.015 | 0.029 | 0.009 | 0.090 | 0.001 | 0.109 |
| | Percent Change | 50.84% | | 19.44% | | 27.62% | |
| 3 | Mean | 2.487 | 3.149 | 1.741 | 1.817 | 9.946 | 12.935 |
| | SD | 0.077 | 0.015 | 0.055 | 0.056 | 0.038 | 0.481 |
| | Percent Change | 26.63% | | 4.41% | | 30.06% | |
| 4 | Mean | 2.236 | 3.129 | 1.641 | 1.886 | 10.166 | 11.973 |
| | SD | 0.080 | 0.146 | 0.046 | 0.090 | 0.115 | 0.217 |
| | Percent Change | 39.96% | | 14.92% | | 17.77% | |
| 5 | Mean | 1.284 | 2.499 | 1.134 | 1.454 | 10.397 | 13.730 |
| | SD | 0.132 | 0.271 | 0.083 | 0.082 | 0.275 | 0.161 |
| | Percent Change | 94.59% | | 28.26% | | 32.06% | |

Chemical 40

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.261 | 2.584 | 1.684 | 1.803 | 9.860 | 10.715 |
| | SD | 0.020 | 0.034 | 0.019 | 0.024 | 0.103 | 0.141 |
| | Percent Change | 14.29% | | 7.02% | | 8.67% | |
| 2 | Mean | 2.088 | 2.092 | 1.612 | 1.584 | 10.115 | 10.655 |
| | SD | 0.047 | 0.022 | 0.008 | 0.017 | 0.007 | 0.039 |
| | Percent Change | NS | | -1.73% | | 5.33% | |
| 3 | Mean | 2.464 | 2.637 | 1.734 | 1.746 | 9.906 | 10.647 |
| | SD | 0.099 | 0.067 | 0.063 | 0.057 | 0.006 | 0.276 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.260 | 2.412 | 1.651 | 1.687 | 10.250 | 10.867 |
| | SD | 0.017 | 0.048 | 0.040 | 0.045 | 0.125 | 0.103 |
| | Percent Change | 6.72% | | NS | | 6.02% | |
| 5 | Mean | 1.248 | 2.437 | 1.140 | 1.174 | 10.372 | 16.903 |
| | SD | 0.105 | 0.124 | 0.082 | 0.119 | 0.228 | 1.256 |
| | Percent Change | 95.32% | | NS | | 62.96% | |

Table 2. Continued

Chemical 41

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.254 | 2.463 | 1.667 | 1.770 | 10.089 | 10.913 |
| | SD | 0.028 | 0.023 | 0.012 | 0.040 | 0.141 | 0.162 |
| | Percent Change | 9.25% | | NS | | NS | |
| 2 | Mean | 2.065 | 2.262 | 1.608 | 1.670 | 10.284 | 10.809 |
| | SD | 0.008 | 0.030 | 0.008 | 0.012 | 0.000 | 0.003 |
| | Percent Change | 9.57% | | 3.88% | | 5.11% | |
| 3 | Mean | 2.444 | 2.678 | 1.728 | 1.676 | 10.145 | 11.314 |
| | SD | 0.014 | 0.015 | 0.015 | 0.160 | 0.001 | 0.540 |
| | Percent Change | 9.57% | | NS | | NS | |
| 4 | Mean | 2.247 | 2.552 | 1.627 | 2.517 | 10.153 | 10.756 |
| | SD | 0.058 | 0.066 | 0.052 | 0.022 | 0.132 | 0.070 |
| | Percent Change | 13.56% | | 54.75% | | 5.93% | |
| 5 | Mean | 1.288 | 1.504 | 1.131 | 1.217 | 10.949 | 11.771 |
| | SD | 0.084 | 0.118 | 0.083 | 0.068 | 0.072 | 0.351 |
| | Percent Change | 16.77% | | 7.56% | | 7.51% | |

Chemical 42

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.262 | 2.318 | 1.663 | 1.669 | 10.079 | 10.316 |
| | SD | 0.009 | 0.010 | 0.002 | 0.015 | 0.082 | 0.150 |
| | Percent Change | 2.48% | | NS | | NS | |
| 2 | Mean | 2.097 | 2.244 | 1.614 | 1.585 | 10.215 | 10.172 |
| | SD | 0.042 | 0.298 | 0.007 | 0.007 | 0.000 | 0.048 |
| | Percent Change | NS | | -1.84% | | NS | |
| 3 | Mean | 2.442 | 2.463 | 1.738 | 1.689 | 10.240 | 10.377 |
| | SD | 0.066 | 0.060 | 0.043 | 0.034 | 0.216 | 0.258 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.256 | 2.303 | 1.652 | 1.641 | 10.351 | 10.374 |
| | SD | 0.049 | 0.034 | 0.014 | 0.003 | 0.444 | 0.242 |
| | Percent Change | 2.08% | | NS | | NS | |
| 5 | Mean | 1.245 | 2.278 | 1.154 | 1.174 | 10.427 | 10.488 |
| | SD | 0.098 | 0.089 | 0.069 | 0.069 | 0.170 | 0.166 |
| | Percent Change | NS | | 1.73% | | NS | |

Table 2. Continued

Chemical 43

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.284 | 2.366 | 1.687 | 1.741 | 10.142 | 10.220 |
| | SD | 0.031 | 0.044 | 0.016 | 0.040 | 0.012 | 0.019 |
| | Percent Change | 3.58% | | NS | | 0.78% | |
| 2 | Mean | 2.088 | 2.114 | 1.621 | 1.590 | 10.096 | 10.129 |
| | SD | 0.015 | 0.017 | 0.005 | 0.019 | 0.025 | 0.045 |
| | Percent Change | 1.28% | | NS | | NS | |
| 3 | Mean | 2.506 | 2.569 | 1.733 | 1.702 | 10.108 | 10.315 |
| | SD | 0.026 | 0.055 | 0.021 | 0.029 | 0.111 | 0.241 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.154 | 2.204 | 1.638 | 1.635 | 9.761 | 9.841 |
| | SD | 0.072 | 0.073 | 0.029 | 0.016 | 0.512 | 0.528 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.215 | 1.335 | 1.160 | 1.100 | 10.478 | 11.075 |
| | SD | 0.063 | 0.081 | 0.086 | 0.077 | 0.384 | 0.407 |
| | Percent Change | NS | | NS | | NS | |

Chemical 44

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.281 | 2.300 | 1.686 | 1.694 | 10.147 | 10.135 |
| | SD | 0.027 | 0.027 | 0.020 | 0.016 | 0.076 | 0.097 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.048 | 2.052 | 1.599 | 1.586 | 9.835 | 9.980 |
| | SD | 0.037 | 0.039 | 0.024 | 0.030 | 0.002 | 0.061 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.504 | 2.536 | 1.768 | 1.734 | 9.703 | 9.998 |
| | SD | 0.032 | 0.033 | 0.026 | 0.025 | 0.230 | 0.058 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.231 | 2.243 | 1.643 | 1.641 | 10.138 | 10.194 |
| | SD | 0.014 | 0.020 | 0.024 | 0.034 | 0.128 | 0.237 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.148 | 1.218 | 1.100 | 1.085 | 10.008 | 10.293 |
| | SD | 0.110 | 0.115 | 0.076 | 0.077 | 0.402 | 0.750 |
| | Percent Change | NS | | -1.42% | | NS | |

Table 2. Continued

Chemical 45

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.261 | 3.421 | 1.682 | 1.894 | 10.089 | 13.229 |
| | SD | 0.034 | 0.034 | 0.022 | 0.032 | 0.105 | 0.176 |
| | Percent Change | 51.30% | | 12.63% | | 31.12% | |
| 2 | Mean | 2.066 | 2.561 | 1.593 | 1.700 | 10.131 | 10.985 |
| | SD | 0.014 | 0.019 | 0.023 | 0.049 | 0.002 | 0.054 |
| | Percent Change | 23.94% | | NS | | 8.43% | |
| 3 | Mean | 2.566 | 2.620 | 1.799 | 1.896 | 10.279 | 10.489 |
| | SD | 0.034 | 0.323 | 0.026 | 0.270 | 0.185 | 0.272 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.238 | 3.426 | 1.609 | 2.004 | 10.873 | 13.138 |
| | SD | 0.091 | 0.209 | 0.025 | 0.050 | 0.440 | 0.146 |
| | Percent Change | 53.08% | | 24.54% | | 20.84% | |
| 5 | Mean | 1.275 | 4.515 | 1.139 | 0.655 | 10.664 | 18.628 |
| | SD | 0.074 | 0.507 | 0.088 | 0.121 | 0.336 | 0.449 |
| | Percent Change | 254.15% | | -42.51% | | 74.68% | |

Chemical 46

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.258 | 2.279 | 1.674 | 1.667 | 10.061 | 10.096 |
| | SD | 0.015 | 0.015 | 0.010 | 0.008 | 0.111 | 0.096 |
| | Percent Change | NS | | -0.44% | | NS | |
| 2 | Mean | 2.027 | 2.049 | 1.583 | 1.571 | 10.210 | 10.346 |
| | SD | 0.045 | 0.043 | 0.009 | 0.022 | 0.167 | 0.303 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.593 | 2.644 | 1.825 | 1.809 | 10.183 | 10.255 |
| | SD | 0.042 | 0.045 | 0.045 | 0.050 | 0.123 | 0.255 |
| | Percent Change | NS | | -0.88% | | NS | |
| 4 | Mean | 2.199 | 2.252 | 1.626 | 1.614 | 10.269 | 10.345 |
| | SD | 0.079 | 0.085 | 0.045 | 0.037 | 0.026 | 0.221 |
| | Percent Change | 2.45% | | NS | | NS | |
| 5 | Mean | 1.161 | 1.202 | 1.137 | 1.123 | 10.141 | 10.401 |
| | SD | 0.115 | 0.115 | 0.100 | 0.102 | 0.455 | 0.390 |
| | Percent Change | 3.51% | | -1.23% | | 2.56% | |

Table 2. Continued

Chemical 47

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.260 | 2.312 | 1.691 | 1.704 | 10.114 | 10.099 |
| | SD | 0.052 | 0.061 | 0.016 | 0.023 | 0.160 | 0.081 |
| | Percent Change | NS | | NS | | NS | |
| 2 | Mean | 2.048 | 2.075 | 1.588 | 1.555 | 10.098 | 10.291 |
| | SD | 0.015 | 0.019 | 0.013 | 0.005 | 0.072 | 0.107 |
| | Percent Change | NS | | NS | | NS | |
| 3 | Mean | 2.536 | 2.587 | 1.806 | 1.773 | 10.203 | 9.964 |
| | SD | 0.053 | 0.046 | 0.040 | 0.036 | 0.285 | 0.427 |
| | Percent Change | 2.02% | | NS | | NS | |
| 4 | Mean | 2.242 | 2.353 | 1.662 | 1.707 | 10.153 | 10.186 |
| | SD | 0.057 | 0.038 | 0.035 | 0.037 | 0.018 | 0.063 |
| | Percent Change | 4.96% | | 2.73% | | NS | |
| 5 | Mean | 1.227 | 1.246 | 1.136 | 1.185 | 10.423 | 10.435 |
| | SD | 0.059 | 0.029 | 0.109 | 0.147 | 0.578 | 0.576 |
| | Percent Change | NS | | NS | | NS | |

Chemical 48

| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
|---|---|---|---|---|---|---|---|
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.293 | 2.600 | 1.688 | 1.818 | 10.157 | 13.411 |
| | SD | 0.016 | 0.033 | 0.017 | 0.024 | 0.025 | 0.108 |
| | Percent Change | 13.37% | | 7.69% | | 32.03% | |
| 2 | Mean | 2.073 | 3.131 | 1.606 | 2.027 | 9.770 | 13.502 |
| | SD | 0.041 | 0.021 | 0.023 | 0.010 | 0.129 | 0.033 |
| | Percent Change | 51.05% | | 26.23% | | 38.20% | |
| 3 | Mean | 2.578 | 3.129 | 1.807 | 1.773 | 10.132 | 11.803 |
| | SD | 0.039 | 0.037 | 0.022 | 0.107 | 0.004 | 0.475 |
| | Percent Change | 21.36% | | NS | | 16.50% | |
| 4 | Mean | 2.271 | 3.415 | 1.651 | 1.883 | 10.805 | 13.964 |
| | SD | 0.102 | 0.410 | 0.010 | 0.069 | 0.503 | 0.248 |
| | Percent Change | 50.41% | | 14.05% | | 29.24% | |
| 5 | Mean | 1.148 | 1.798 | 1.100 | 0.959 | 10.008 | 12.312 |
| | SD | 0.110 | 0.051 | 0.076 | 0.183 | 0.402 | 1.017 |
| | Percent Change | 56.64% | | NS | | 18.85% | |

Table 2. Continued

| Chemical 49 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.257 | 2.328 | 1.665 | 1.715 | 10.067 | 7.260 |
| | SD | 0.023 | 0.016 | 0.021 | 0.008 | 0.027 | 5.293 |
| | Percent Change | NS | | 3.02% | | NS | |
| 2 | Mean | 2.077 | 2.133 | 1.587 | 1.583 | 10.125 | 10.321 |
| | SD | 0.024 | 0.020 | 0.021 | 0.018 | 0.042 | 0.049 |
| | Percent Change | 2.70% | | NS | | 1.93% | |
| 3 | Mean | 2.638 | 2.663 | 1.826 | 1.810 | 10.084 | 10.764 |
| | SD | 0.057 | 0.047 | 0.022 | 0.016 | 0.175 | 0.266 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.233 | 2.287 | 1.638 | 1.640 | 10.281 | 10.345 |
| | SD | 0.076 | 0.080 | 0.040 | 0.045 | 0.464 | 0.280 |
| | Percent Change | NS | | NS | | NS | |
| 5 | Mean | 1.148 | 1.505 | 1.100 | 1.066 | 10.008 | 10.166 |
| | SD | 0.110 | 0.120 | 0.076 | 0.167 | 0.402 | 0.306 |
| | Percent Change | NS | | NS | | NS | |
| Chemical 50 | | | | | | | |
| Material | Test | Weight (g) | | Thickness (mm) | | Surface Area (SqCm) | |
| | | Pre | Post | Pre | Post | Pre | Post |
| 1 | Mean | 2.312 | 2.320 | 1.661 | 1.714 | 10.143 | 10.276 |
| | SD | 0.123 | 0.011 | 0.008 | 0.004 | 0.058 | 0.014 |
| | Percent Change | NS | | 3.16% | | NS | |
| 2 | Mean | 2.060 | 2.139 | 1.592 | 1.590 | 9.992 | 10.280 |
| | SD | 0.027 | 0.017 | 0.015 | 0.014 | 0.026 | 0.143 |
| | Percent Change | 3.85% | | NS | | NS | |
| 3 | Mean | 2.616 | 2.692 | 1.841 | 1.815 | 10.305 | 10.369 |
| | SD | 0.020 | 0.021 | 0.008 | 0.013 | 0.090 | 0.126 |
| | Percent Change | NS | | NS | | NS | |
| 4 | Mean | 2.265 | 2.336 | 1.652 | 1.647 | 10.101 | 10.214 |
| | SD | 0.021 | 0.021 | 0.014 | 0.019 | 0.056 | 0.151 |
| | Percent Change | 3.16% | | NS | | NS | |
| 5 | Mean | 1.219 | 1.334 | 1.161 | 1.166 | 10.549 | 10.818 |
| | SD | 0.055 | 0.057 | 0.092 | 0.089 | 0.374 | 0.368 |
| | Percent Change | 9.40% | | NS | | 2.55% | |

Footnote. This table contains all of the statistical analysis data, including Mean, standard deviation, and Percent change. All values for percent change were significant if listed. A NS label was given to those that had a P value greater the 0.05. Material 1= Neoprene, 2=Butyl rubber, 3= Nitrile, 4=Vinyl, 5=Latex.

The percent change data were compared between the weight change and the surface area change. When compared graphically the regression line given was Y=0.4841x + 0.0187 and the $R^2$ value was 0.9096. This graph (Figure 1) shows that there is strong correlation (Pearson r = 0.9519; $p \leq 0.05$) between percent weight change and percent surface area change. On average, the percent change for surface area was about half that of the weight change, slope 0.48, which indicates that surface area may be a more sensitive measure of degradation in comparison with weight change. Using this information and the ASTM weight percent change degradation ratings[8], Table 3, a rating system for percent change of surface area for glove degradation was created. See Table 4.

Figure 1: Correlation Between Percent Weight Change and Percent Surface Area Change

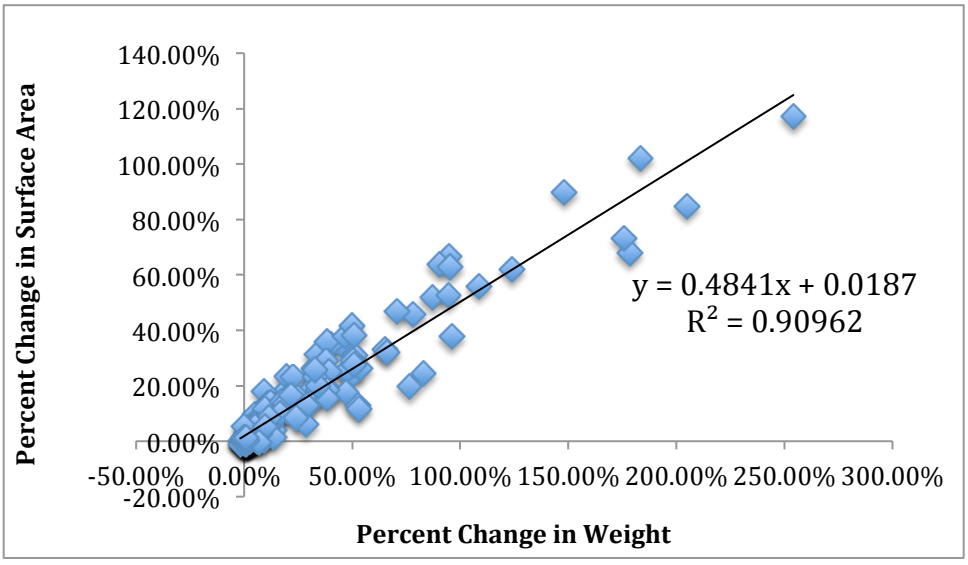

Table 3: American Society for Testing Materials Method D471 Degradation Ratings for Weight Change

| Weight Degradation Rating | Percent Change |
|---|---|
| Excellent | 0-10% |
| Good | 11-20% |
| Fair | 21-30% |
| Poor | 31-50% |
| Not Recommended | >50% |

Footnote: This table was made from the information supplied by *Chemical Protective Clothing* (7). It is the current rating system uses by ASTM to determine the degradation ratings for gloves based on weight change.

Table 4: Developed Degradation Rating System for Surface Area Change

| Surface Area Degradation Rating | Percent Change |
|---|---|
| Excellent | 0-5% |
| Good | 6-10% |
| Fair | 11-15% |
| Poor | 16-25% |
| Not Recommended | >25% |

Footnote: The developed rating system for the degradation of gloves using surface area change. This chart was developed based on the regression line of Figure 1 and the information contained in Table 3.

The surface area rating system (Table 4) gave similar results to that of the weight change rating system. In almost every chemical and glove combination (89.6%) the ratings given by the weight and surface area are consistent with each other. The ratings were also in line for the samples that showed no significant change in surface area but did show changes in weight. In these instances all the percent changes are well under 10% change so these gloves would be considered an excellent choice. Having no significant surface area

change these gloves would also be deemed an excellent choice. So even though, there was significant change in the weight change but no significant change in the surface area both tests gave the same degradation rating of excellent. There are a few cases (10.4%) when the surface area rating gave the glove a lower rating than that of the weight. An example of this is seen in Table 2 Chemical 12. The weight change rating given would fall in the fair category, where the surface area change rating places it in the not recommended category. In only 0.8% of the cases, weight change gave a lower rating than that of surface area. This would indicate that the surface area test is more conservative, and possibly more sensitive than weight change.

# CHAPTER FOUR

# CONCLUSIONS AND RECOMMENDATIONS

## Conclusion

Using the percent change of surface area, following exposure to a chemical agent, is a valid method for the determination of the degradation of polymer materials and gloves. The Pearson r value for the correlation between weight and surface area change was $r = 0.9519$ ($p \leq 0.05$), indicating that there was a strong correlation between weight change and surface area change. The degradation changes in the polymer materials are shown in both the weight and surface area, and changes are in accordance with one another. The weight changes are about double that of the surface area changes, which indicates that the surface area method is more sensitive than the gravimetric determination. The linear regression was used to determine a rating system for surface area change in relation to the weight change degradation rating system. When using this newly developed rating system, it has been shown that for nearly all (89.6%) of the surface area ratings matched that of the weight ratings.

This new method for determining the degradation of gloves is less expensive than that of the current method. This method requires glove samples, chemicals for testing, small glassware, a digital scanner, and NIH's ImageJ software. It was shown in this study that surface area change is as effective as using weight change. Because this method is effective, simple, and less costly

than current degradation methods, it could be used by a variety of companies, businesses, and labs that are in need of degradation data to ensure their employees are wearing the proper chemical protective gloves and even clothing materials. With this method, it would be easy for an individual or employers to determine an appropriate chemical resistant glove type (or even clothing) to use for the chemicals they are handling on a daily basis. This would also facilitate compliance with OSHA's laws and regulations requiring employers to supply appropriate PPE for their employees.

## Future Recommendations

Further studies are needed. There were a limited number of chemicals and gloves tested in this study. Another study testing more chemicals with a wider variety of polymer materials should be done. Also, this study was done with no change in temperature so a comparison of weight and surface area changes in relation to chemicals at an increased temperature should be performed, especially at skin temperature. There is no information if temperature change would significantly affect the surface area changes in the same way as the heat with weight change or chemical degradation. Lastly, chemical permeation, molecular movement through the polymer material, is still an important consideration when selecting chemical protective clothing. Inexpensive and efficient permeation tests also need to be developed alongside these degradation tests.

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