Lauren Cho
1/17/17

Annotated Source List

Amarit, R., Kopwitthaya, A., Pongsoon, P., Jarujareet, U., Chaitavon, K., Porntheeraphat, S., . . . Koanantakool, T. (2016). High-quality large-magnification polymer lens from needle moving technique and thermal assisted moldless fabrication process. *US National Library of Medicine National Institutes of Health.* http://dx.doi.org/10.1371/journal.pone.0146414

Summary: Online Journal

Published online for public-access this brief **scientific research paper** seeks to explore the different effects that the needle-moving technique has on various optical properties as well as if high-powered microscope lens could be created from curing PDMS. The researchers developed an efficient method to minimize the number of air bubbles and debris caught on the PDMS lens while it was curing. Basically, the experimenters use the needle-moving technique to create a spherical lens with an upward curvature against the force of gravity, or without hanging the PDMS droplet upside-down. They then cure the PDMS extremely quickly by exposing the polymer on a glass slide to 200 degrees Celsius of heat for thirty seconds. The uniformity of the lens would be achieved, and hence, a small PDMS lens with 170X magnification can be created.

Applications to Research:

This research's findings will be extremely useful to my research and experimentation at my internship. I can try to follow the procedure detailed in the paper and analyze what types of lens I cure as a result. I can also try to use the various equations to better understand how to calculate various parameters of the lens such as focal length, resolution, and magnification power. I believe that following through the needle-moving method could help me better picture what other techniques I could use in curing PDMS to create the most efficient PDMS realistic PDMS lens which could be used in a microscope the size of the Foldscope. Perhaps I could also use the PDMS lens on mobile devices such as phones or tablets.

Beadie, G., Sandrock, M. L., Wiggins, M. J., Lepkowicz, R. S., Shirk, J. S., Ponting, M., . . . Baer, E. (2008). Tunable polymer lens. *The Optical Society*, *16*(16), 11847-11857. https://dx.doi.org/10.1364/OE.16.011847

Summary: Online Journal

Found off the Optical Society's website **open-access scientific article** seeks to detail how to make the most efficient variable lens similar to the human-eye lens using an all-solid state polymer lens. These solid-state lens are more robust and resistant to fluctuations in temperature, pressure, and motion. The paper described the manufacturing process of the lens they created from cross-linking multiple polymers. The researchers used metal molds to apply pressure both inside and outside of the elastomer fluid. The metal brace-polymer assembly was heated for 15 minutes at 120 degrees Celsius. Also, this paper discusses the benefits of using elastomeric lens instead of hard, inflexible lens material. For instance, the lens surface is well-defined and sagging due to gravity does not occur as much. The lens created by the authors of the paper are suited for optical use in patients; for patients' corrective lens.

Applications to Research:

This source will be helpful to my research project because the paper gives me more insight into how optics work and what properties polymers provide as being the raw material for lens. Secondly, I can read and study this source more in-detail so that I may gain a better understanding of how to conduct my experiment: what variables to control, what variables may be changed, what can be used to fix some challenges and problems I face when curing PDMS lens. Also, this source has lots of mathematical equations and explanations as to how to calculate certain measurements related to polymer optics lens.

Campbell, D. J. (2017, January 9). Re: Question about your research [E-mail to the author].

Summary: Personal Email

Self-drafted and sent to Dr. Dean Campbell this **email** seeks for a response answering questions about the website about various PDMS-based experiments. Dr. Dean Campbell was referenced in the University of Wisconsin's Interdisciplinary Education Group webpage discussing the various uses of polydimethylsiloxane (PDMS). He is currently a professor at Bradley University and he completed his postdoctoral at the University of Wisconsin-Madison. On the webpage, there is a short portion referencing him for any further questions or comments. In attempt to complete some human networking, Dr. Dean Campbell was contacted for further information he could give on curing PDMS, the structure of PDMS, cross-linking reactions, or any further feedback on the entire process of curing the polymer.

Applications to Research:

Although I probably will not use this source in my final paper, this source is directly useful and practical to the research and experimentation I am conducting this year at my internship. So far, while working on different parameters and methods to curing PDMS to find the optimal process or method, I have seen many problems I run into, one of which involves the removal of PDMS from the glass surface cleanly. I've researched multiple methods so far, and none seem realistic or practical to my own experiment. By contacting Dr. Campbell I think I have gained more insight on the chemical processes which allow for the PDMS to cross-link as well as ideas on how to improve my research, as well as on any future experiments. Dr. Campbell also gave me a simple method on the process of curing PDMS, rather than with any complex equipment or terminology. I believe further networking with Dr. Campbell will be extremely useful to the advancement of my research and experimentation.

Campbell, D. J., Beckman, K. J., Calderon, C. E., Doolan, P. W., Moore, R. H., Ellis, A. B., & Lisensky, G. E. (2006). Uses of polydimethylsiloxane (PDMS) elastomer. Retrieved November 13, 2016, from http://education.mrsec.wisc.edu/background/PDMS/

Summary: Website

Found off the University of Wisconsin-Madison's website this **scientific article** seeks to detail the overall background information on how PDMS lens are cured, specifically for Dow Corning Sylgard Elastomer 184. PDMS is cured by an organometallic cross-linking reaction. The siloxane base oligmers contain vinyl groups, and the cross-linking oligmers contain at least three silicon hydride bonds each. The curing agent has a platinum-based catalyst which catalyzes the addition of SiH bonds across the vinyl groups, forming $Si\text{-}CH_2\text{-}CH_2\text{-}Si$ chains. There are multiple reaction sites which allows for three-dimensional cross-linking to occur. This addition reaction is desirable because no waste byproducts are created. Increasing the curing agent-base ratio allows for a more cross-linked PDMS elastomer to be created. Heat also serves to hasten the reaction. Also, four potential experiments are linked to this webpage, which explore various aspects of PDMS and its properties.

Applications to Research:

This source will be helpful to my research project because I can better understand how the curing process works and what chemical interactions are actually occuring. Another useful aspect of this source is that Dr. Dean Campbell's email is provided on the webpage so that I could contact him for any further questions or discussions on the PDMS topic as well as to get a better understanding of the subject. I also can look at pictures that are provided and see what other college researchers have been doing with PDMS, and how that information can apply to what I experiment on at my internship, because at UMBC I am provided with the same PDMS brand.

Cybulski, J. S., Clements, J., & Prakash, M. (2014). Foldscope: Origami-based paper microscope. *PLoS ONE*, *9*(6). http://dx.doi.org/10.1371/journal.pone.0098781

Summary: Online Journal

Written by college professors and researchers from Stanford University, this **journal** provides a great, easy-to-understand, yet technical introduction and overview of microscopy and optics. An abstract is provided, as well as introductory information to optics and microscopy and supplementary material. The source provides readers with pictures of the Foldscope paper-origami microscopes, the pictures of images as viewed through the microscope, and many other diagrams, data, and videos explaining various concepts needed to better comprehend the design and function of the microscope. Interestingly, the source integrates the principles behind origami and paper, such as forces involved and durability and flexibility with a description of how a microscope works. The source also explains the various types of microscopy which exist, and an brief description of how Foldscope can be specialized in each type of microscopy.

Applications to Research:

This scientific research paper seems to be a great source for me to use, perhaps the one most crucial to my own research project this year, since the project itself stems off this research and discovery/invention of origami-paper microscopes by the researchers from Stanford. I can refer to this source many times, since it introduces many concepts and terminology I must know and understand in order to research my project effectively this year. The source is so fantastic that it also provides me pictures, data, blueprints of the microscope, a video, and many other materials to me. There is also a list of references and supplementary material that I may use to locate other sources and more thoroughly investigate my research question. This source models what invention or "final product" I am working to optimize and improve upon.

Dow Corning. (n.d.). *Sylgard 184 elastomer kit* [Fact sheet]. Retrieved October 19, 2016, from Dow Corning website: http://www.dowcorning.com/applications/search/default.aspx?R=131EN

Summary: Website

Found off the manufacturer's website, this **PDMS chemical property sheet** serves to list the properties of the specific brand and isomer type of PDMS curing kit used—Sylgard 184 Silicone Elastomer Kit. For instance, there are three subcategories of properties of the polymer: the typical properties, characteristics, and regulations. In the first subcategory, properties such as appearance color, thermal conductivity, water resistance, mix ratio, polarity, and other properties are listed. Under characteristics, compatibilities with other materials, cure properties, general properties, product-use properties, resistance, and thermal properties are listed. Finally, under the third tab, approvals from various regulation companies are listed. Also, found on the site are links to downloadable pdf Safety Data Sheets and Product Data Sheets with more information on the Sylgard 184 PDMS.

Applications to Research:

This source will be incredibly useful to me in obtaining knowledge necessary for handling PDMS when working to cure PDMS lenses. I can figure out the ratio required of base:curing agent and the baking temperature and time required for me to cure PDMS. Also, specific properties are explained so thoroughly and an overflowing amount of data is provided, so I can always relate a certain tendency I see to one of this polymer's properties, such as being extremely hydrophobic or being clear. Another advantage of this source is that is should be very much credible as Dow Corning, the manufacturer of the PDMS Silicone Elastomer Kit, provided intricate properties on its product for its customers.

Eddings, M. A., Johnson, M. A., & Gale, B. K. (2008). Determining the optimal PDMS–PDMS bonding technique for microfluidic devices. *Journal of Micromechanics and Microengineering*, *18*. http://dx.doi.org/10.1088/0960-1317/18/6/067001

Summary: Online Journal

Published online this brief **scientific research paper** seeks to discover which of five factors has the greatest impact on PDMS-PDMS bonding. First off, the researchers made use of the hydrophobic, nonconformal contact of two fully-cured layers of PDMS. Surface oxidation was used to increase the exposure of silanol (-OH) groups to the air, hence increasing bond strength. Oxygen plasma treatments are helpful because they allow PDMS to be a bit more hydrophillic, allowing PDMS to more easily bond to other materials such as glass. Another method relied on using a stickier layer of PDMS with a less cross-linking agent. The advantage of the method is that the PDMS could easily mold a device without worries of contamination between the PDMS bonds. Another method possibly used is the "Stamp-and-Stick" method, in which uncured PDMS or other adhesives are used to bond PDMS layers together. Also used was the curing agent specifically as the adhesive to stick layers of PDMS together. Finally, a technique used was called Corona discharge, as high voltage potential is created by a corona device to ionize the air surrounding the PDMS. Uncured PDMS adhesive and partial curing were most effective in bond strength, then varying the curing ratio and the oxygen plasma method, and finally corona discharge as least effective.

Applications to Research:

This research's findings are relevant to my project, but honestly may not exactly be what I am looking for, as I need to find a cheap, effective method of curing PDMS lens. Although layering PDMS could be effective, it may be unrealistic as the lens created will be small.

European Centre for Ecotoxicology and Toxicology of Chemicals. (2011, December). *JACC Report: Vol. 55. Linear polydimethylsiloxanes* (Technical Report No. CAS No. 63148-62-9). Retrieved from http://www.ecetoc.org/wp-content/uploads/2014/08/JACC-055-Linear-Polydimethylsiloxanes-CAS-No.-63148-62-9-Second-Edition.pdf

Summary: Online Technical Report

Found off the European Centre for Ecotoxicology and Toxicology of Chemicals (ECETOC) website, this informational **technical report** seeks to inform readers about the various hazards and properties that polydimethylsiloxane poses to the environment, society, as well as with other chemicals and organisms. PDMS does not pose much of a threat to the ecosystem other than the fact that it not a very biodegradable material. Also, PDMS does not have any known effects on underwater organisms such as fish or daphnia, although it can kill insects. To humans, no lethal symptoms are shown when PDMS is ingested orally or applied on the skin. Thus, the researchers have concluded PDMS is not extremely harmful to the environment and toxic to human health. Also, the report also discusses PDMS's effect with other chemicals, its metabolism, kinetics, and other information of interest solely on PDMS.

Applications to Research:

There is so much information provided specifically about PDMS in this report that it would deem to be an extremely useful source. Also, this report is 155 pages long, and although I would not read the entire source, I could skim and locate specific parts of the report which would serve to be useful (as a reference) to my experiment as well as research paper that I must write later. Also, the report discusses many of the major applications of PDMS, which I find useful.

Halliday, D., Resnick, R., Walker, J., Newman, H., Melhorn, A., & Baley, M. (2005). Images. In S. Johnson, E. Ford, & E. Swain (Eds.), *Fundamentals of physics* (7th ed., pp. 924-947). Danvers, MA: John Wiley & Sons.

Summary: Print Reference Source

Found in an introductory college-level physics textbook, this **chapter** serves to explain the specifics and overview information on images, and the process from which images are formed of a light source, when an optical instrument redirects rays from the light source. Background information on mirrors, thin lens, refraction, lateral magnification as well as optical instruments is provided. Definition of specific terminology in optics as specific processes to locate images from a certain optical device, as well as equations are thoroughly explained throughout this chapter. The equations are derived through taking derivatives, combining equations, and integration, with each step described in detail. Therefore, I can not only understand what an equation is but why a certain equation relates certain variables, and how they are useful.

Applications to Research:

Because the chapter is a college-level source, unlike the first source, which too was a high school AP science textbook, the textbook I use for Physics C, is not AP-edition and is older and harder to understand, with denser information. However, this element makes this textbook chapter a much more valuable source, if understood, because more details, information, equations, images, as a well as sample problems are provided. I find the entire chapter very insightful, yet find the section on the compound microscope (pages 942-943) most specific to the microscopy and optics research project I have this year. This source, like the first source, can be used as introductory material to locate other, more complex sources on optics, and comprehend the material. This source helps give me information on my research topic from the physics content area.

Hourlier-Fargette, A., Antkowiak, A., Chateauminois, A., & Neukirch, S. (2016). Role of uncrosslinked chains in the sliding dynamics of droplets on elastomers. *Cond-mat.soft*. http://dx.doi.org/1611.09644v1

Summary: Online Journal

Found online as a free, accessible source, this **online journal** seeks to inform readers about the crucial role uncrosslinked oligmers in the PDMS play in the roles of sliding water droplets down a PDMS surface. This paper is written by authors from a French university's physics department. In simple terms, the researchers used Sylgard 184 silicone elastomer base and its corresponding curing agent in a 10:1 ratio, curing a PDMS plate at 60 degrees Celsius for 2 hours. They explained a PDMS surface is different from a glass surface since water has two distinct speeds traveling on the surface of PDMS, but has only one on the glass surface. PDMS was placed into a toluene bath for a week, then placed in ethanol a second week, and eventually placed in an oven to evaporate the solvents. 5% mass loss resulted from the treatment, accounting for the mass of the uncrosslinked oligmers. Also, water droplets that were allowed to slide down the PDMS surface had one sliding regime, or speed, like glass. To recover the lost uncrosslinked oligmers, the researchers swelled PDMS with PDMS v50 oil from the manufacturer Sigma Aldrich. Many equations and concepts are referenced in this relatively short paper.

Applications to Research:

This paper will be practical to use in my final paper as a source I can use to explain some phenomena that I found in my experimental data. Also, knowing that the presence and amount of uncrosslinked PDMS oligmers is crucial to the properties of water (a polar molecule) interacting with a PDMS surface (a nonpolar molecule) would be useful to explore other deviations in my research and labs.

Johnston, E. (2016, March 1). *Degassing PDMS in a vacuum dessicator* [Video file]. Retrieved from https://www.youtube.com/watch?v=J9pCHh4OmZI

Summary: Online Video

Found on Youtube, this **video**, like the first source, is a step-by-step guide on how to cure PDMS. However, this source has no narration, but instead captions which go into more scientific detail into how the process works. Also, the person who posted the video is different from the creator of the video. In the beginning, a screen appears which reads Penn Singh Center for Nanotechnology, suggesting that this source is more valid and credible in terms of information provided. The first step to curing PDMS, as stated by the creator, Joseph Song, is to "Mix a desired amount of PDMS at 10:1 base:cure by weight ratio." He then writes "Mix desired amount of PDMS at 10:1 base:cure by weight ratio." Next, "Degas the mixture under vacuum until clear," and then "Pour PDMS to a depth of 7 mm over each water on a level of aluminum block." After this step, "Degas until clear," finally, "Transfer block to 80 C oven and cure it for at least 70 min." Song also physically conducts each step in his procedure in the video while he describes the step in the caption.

Applications to Research:

Like the first source, this source will be useful to helping me create a better picture of what I will do over the course of this year in the UMBC chemistry lab under my mentor's supervision. I find this source quite reliable as it is more detailed than the first, and seems to be created with relation to University of Pennsylvania. However, some processes still seem vague, and the creator of the video does not explicitly state all the materials used. From watching this video, I have still learned a lot of information.

Kamali, S. M., Arbabi, E., Arbabi, A., Horie, Y., & Faraon, A. (2016). Highly tunable elastic dielectric metasurface lenses. *Caltech*, 1-10. Retrieved from http://authors.library.caltech.edu/66564/1/1604.03597v1.pdf

Summary: Online Journal

Found off the Caltech's online library, this **scientific research paper** seeks to explain how PDMS lens can be tuned due to its physical elastic property as well as its ability to serve as a dielectric metasurface, which would manipulate phase and polarization of optical waves. While keeping limited focusing and high efficiency, the technique of tuning the microlens deems extremely useful, as the focal length can be improved by 130%. Also, various measurement techniques and equations are specified in the paper. Also, there seems to be a lot of images of various imaging of the molecules and optical properties.

Applications to Research:

The information in the paper isn't long, but it's extremely dense! I know I will have to reread this source and may need my mentor's help as well as additional research on understanding what the dielectric metasurface exactly is. However, if I am able to better understand the source and what the procedure that was done exactly did to increase focal length without loss of resolution of magnification, then the source will deem to be extremely helpful for my experiments curing PDMS as well as the other research I conduct for my project this year. Also, I would get a better sense of how microscopy and optics really work together hand-in-hand. I'm not sure exactly how I can apply this to my PDMS-curing experiments, but I really hope I can somehow incorporate a part of this information into curing PDMS lens with greater focal length with similar other optical properties.

Kennedy, E. (2016, October 24). [Personal interview by the author].

Summary: Personal Interview

Self-drafted, conducted, and transcribed, this **interview** seeks responses with detail regarding the college chemistry research lab as well as PDMS and background about the interviewee, Erin Kennedy. Erin Kennedy is a graduate research student at UMBC Department of Chemistry and Biochemistry. The interview lasted for approximately half an hour and discusses Kennedy's experiences with graduate research, her personal background and exposure to science, as well as her future goals from her current status. Also, Kennedy gave lots of advice on various aspects of college life, majors, and research in order to become a successful chemistry PhD graduate student. She also discussed details about my prospective research and her own research.

Applications to Research:

This interview was actually conducted on Erin Kennedy at the last minute. I was supposed to interview Noah Robinson, another graduate student in the same research lab, but my mentor switched who I will be working with right on that day I conducted the interview. Hence, I was exchanging introductions with Erin Kennedy as well as asking her detail-oriented questions regarding PDMS. I thought the interview was rather informal. We ended up talking a lot about her background before ending up as a chemistry PhD student at UMBC, her previous research experiences, as well as procedures that might be good for me to know in research. I also gained insight and career advice about becoming a PhD student. Thus, although Kennedy did not know much about PDMS itself other than what information could be found online, she had great advice on college level research and experiences, the research projects the Kyoung lab is now conducting, as well as personal background growing up in a more urban area with less emphasis and support for education.

Kuo, A. C. M. (1999). Poly(dimethylsiloxane) [PDF]. *Polymer Data Handbook*, 411-435. Retrieved from http://www.rubloffgroup.umd.edu/teaching/enma490fall03/resources/current/publications_etc/pdh-735(pdms).pdf

Summary: PDF File

Found as a pdf uploaded by a research group from UMD, this **polymer data handbook** is an extremely detailed reference source listing out the various properties PDMS has. They also provide data of PDMS, when related to other factors and environments, such as in various forms of spectroscopy, properties affecting viscosity, various bond lengths, angles, and energies, gas permeability, interactions with other polymers, and interactions with other materials, such as water. Thermochemical and optical properties are also listed out with specifics. Various health hazards and examples of health hazards, for instance to rabbits, rats, and other test animals are provided. Overall, PDMS is not very toxic. Properties of PDMS as a elastomer and a methylsiloxane resin are also described. Finally major worldwide PDMS producers are provided.
Applications to Research:
This source will not be helpful to me if I read every bit of information from it. Rather, it is more helpful as a source from which I can locate certain properties and specific information I would like to know or connect a property of working with PDMS to. From the characteristics of PDMS provided, I may have a better idea later on as to what and how to improve a certain aspect of PDMS. Also, because specific and accurate scientific terminology is used, I may want to use this as an anchor source, and also bring to my mentor's attention if I really need help understanding a certain aspect or characteristic.

Lee, J. N., Park, C., & Whitesides, G. M. (2003). Solvent compatibility of poly(dimethylsiloxane)-based microfluidic devices. *Analytical Chemistry*, *75*(23), 6544-6554. http://dx.doi.org/10.1021/ac0346712
Summary: Online Journal
From a journal called *Analytical Chemistry*, published by the American Chemical Society, this **scientific paper** provides information on PDMS uses in microfluidic devices for bioanalytics. Lots of background information on PDMS are provided. However, this paper specifically aims to discuss the solvent compatibility of PDMS, often dissolving in nonpolar organic solvents. The experimenters used gravimetric analysis to find the ratio of the mass of swollen PDMS and solvent to that of dry, solid PDMS. Overall, the researchers concluded with the increase in PDMS swelling was the increase in extracted PDMS. The solvents with the most similar solubility parameters with PDMS tended to dissolve the PDMS best. Also, for PDMS swelling to occur, the Gibbs Free Energy must be negative, or favorable. These factors relate through the Hildebrand-Scatchard equation, linking the solubility parameter, δ, to ΔH, or change in enthalpy.
Applications to Research:
Although this source does not focus on the application of PDMS I will specifically use for my research project, I learned a lot about the various interactions PDMS has with various types of chemicals, some acids, bases, and organic and inorganic chemicals I've heard of before. Also, I simply find the source extremely insightful and well-explained, that I understand the uses of PDMS better, and have found other experiments done using PDMS.

Lee, W. M. (2016, December 19). Re: Question about your research [E-mail to the author].
Summary: Personal Email
Self-drafted and sent to Dr. Steve Lee this **email** seeks for a response answering a question about the research Dr. Steve Lee and his researchers at Australian National University conducted on creating hanging-droplet lens. Dr. Steve Lee replied briefly about the overall process of his most recent research as well as including five attachments, three of which are 3-D models of the

PDMS droplet holder parts, one which is a pre-published paper on Lee's most recent research, and another a supplementary attachment to the paper. Dr. Lee also included Tahseen Kamal, a graduate student working in the Lee lab, in his email so that for any further questions, Tahseen could be contacted. The email also aims to establish a human networking connection in order to get access to additional or more intricate information regarding Tahseen and Dr. Lee's research.

Applications to Research:

This email was sent in aim for me to complete one of my human sources required for this quarter for my Intern/Mentor class. I don't believe I will use this in my final annotation list and I suppose I will use another source in replacement of this source. However, from the email I have gotten access to other sources and files which I may not have had access to had I not contacted Dr. Steve Lee. Hence, for my research, I have additional resources from which I can develop my research, background knowledge, and parts of the PDMS curing procedure. Also, interestingly, from skimming and reading through parts of the paper, looking at images and certain explanations, I get a better sense for how the PDMS-curing procedure works, and what its applications are to other fields, such as 3-D printing/imaging as well computer programming. Additionally, I have experts and additional sources in the "References" section to which I can refer to if any questions or comments emerge.

Lee, W. M., Upadhya, A., Reece, P. J., & Phan, T. G. (2014). Fabricating low cost and high performance elastomer lenses using hanging droplets [PDF]. *Biomedical Optics Express*, *5*(5), 1626-1635. http://dx.doi.org/10.1364/BOE.5.001626

Summary: PDF File

Written by many researchers from Australia National University, this article from a scientific **journal** serves to explain the specifics of a technique creating hanging droplets for the function of a lens. Hanging droplets naturally have the ability to illuminate light, specifically LED (light emitting diodes). The equilibrium attained between the "interfacial energies (liquid, air, and solid surface)" (1627) and gravity allow for natural curvature to form on the surface of the droplet, hence allowing for precise focusing. The source further explains the specific use of PDMS (polydimethylsiloxane), a polymer with high performance, durability, transparency, and easy-to-make, by being cured/molded into the shape of a hanging droplet. The source explains the forces, physical and chemical properties, and calculations using various optical measurements, such as refractive indexes, focal lengths, and angles of curvatures formed. A spectrometer was used to measure light intensities of the LED light with and without the PDMS lens, and researchers concluded that the PDMS lens reduces the diverging of LED light, or helps focus light on a certain area. Finally, an interesting application of this technique discussed was that the cured PDMS lens were used in a simple microscope device, which was then attached to a smartphone for a function as a dermoscope.

Applications to Research:

Like the previous source, this source also provides important microscopy and optics background for my research. Information I gained from reading this source was mainly on the properties of PDMS, technique in curing PDMS gel, and knowledge I need in creating a lens for the final microscope I intend to make by the end of this research.

Liebetraut, P., Petsch, S., Liebeskind, J., & Zappe, H. (2013). Elastomeric lenses with tunable astigmatism. *Light: Science & Applications*. http://dx.doi.org/10.1038/lsa.2013.54

Summary: Online Journal
Published online in a scientific journal, this **scientific research paper** serves to inform its audience about the research project that was conducted. The German researchers used Dow Corning's Sylgard 184 Silicone Elastomer Kit to cure PDMS lens. They explored the various optical properties of the PDMS lens and measured the focal length, tuning range, refractive index, numeric aperture, radii of curvature, and various other dimensions to calculate the amount of astigmatism a lens has. The experimenters used Zurnike's polynomial to calculate the wavefront generated by the lens. To create a biconvex elastomeric PDMS lens, a reaction injection process was used. To prevent adhesion of the PDMS during molding, parylene was used. A PDMS precursor was then injected with a syringe and cured for 90 minutes at 90 degrees Celsius. The various lens aberrations were then tuned; including the focal length tuning, astigmatism tuning, and calibration of the actuator.
Applications to Research:
This source will be incredibly useful to me as the experiment conducted directly relates to the project I am conducting as it deals with PDMS curing. Even better, the polymer used in the research is the exact same one I am using at my internship, in the UMBC chemistry laboratory I work in. Also, I find it so interesting that the paper explains how various factors of the lens can be tuned and controlled carefully, so that means I can perhaps manipulate various control variables and receive the certain effect on the lens that I want. Also, I can learn more about optics and use this source as one of my anchor sources of which I can study various optical jargon, various procedures, and types of measurements.

Massachusetts Institute of Technology (MIT). (2016, January 22). *Material may offer cheaper alternative to smart windows* [Video file]. Retrieved from http://news.mit.edu/2016/tune-polymer-material-transparency-smart-windows-0122
Summary: Online Video
Found off the Massachusetts Institute of Technology's website this **video** seeks to summarize and explain the research project that researchers López Jiménez, Pedro Reis, and Kumar Shanmugam were working on. The researchers decided to investigate the simple idea that stretching a rubbery material will make it more transparent and appear "lighter," since more light would pass through. These three researchers decided to cure PDMS as the polymer to investigate, and the three dyed each PDMS sample a different color. The experimenters then stretched and inflated the PDMS samples and shone light through each sample. The researchers were then able to develop an equation similar to the Beer-Lambert Law, which is used to relate concentration of solutions to absorbances of light, for instance, measured by a spectrophotometer. Jiménez, Reis, and Shanmugam concluded that the results of the experiment could be used to develop a covering for windows which could be stretched or compressed to act as a barrier, to control the amount of light passing through the window.
Applications to Research:
Although the project is not directly related to research experiment I am conducting this year, the results of shining light through PDMS is relevant to me. Because I will be curing PDMS lens for optical purposes in a microscope, knowing if I can control the amount of light shone through the sample could help me spark new ideas for experimental investigation at my internship. I could also try to see if I could inflate the PDMS droplet to see if that would increase the amount of light shone through the PDMS sample. It could perhaps function as a diaphragm.

Massachusetts Institute of Technology. (n.d.). Material: PDMS (polydimethylsiloxane) [Table]. Retrieved from http://www.mit.edu/~6.777/matprops/pdms.html

Summary: Website

From the reference section of a free, publicly available MIT website, this **table** serves to list out information about the hydrophobic polymer, polydimethylsiloxane, or PDMS. The reference table provides lots of easy-to-understand, simple information on the intensive physical and chemical properties of PDMS. For instance, the specific heat constant for PDMS is 1.46 KJ/Kg·K, which, when compared to the commonly known specific heat of water, 4.184 KJ/Kg·K, is about four times smaller. Therefore, an implication that PDMS is not a very great temperature moderator can be made. Basically, when heating equal amounts of water and PDMS, the PDMS will have a greater increase in temperature over an equal amount of time. Also provided by the table are various other constants, ratios, compatibilities with other substances, and methods of treatment. The column headings of the table read "Property," "Values," "Reference," "Image/URL (optional)." Thus, there are links to other referenced sources such as papers to explain a certain concept, property, or method involving PDMS.

Applications to Research:

This reference table seems to be an excellent source for my research project despite being short. For instance, from just a single property that PDMS has, I can interpret so many other characteristics of PDMS, such as the analysis I came with above (comparing the specific heat of PDMS with water to get a more holistic view of how well of a temperature moderator PDMS is). Also, I find knowing the various chemical and physical properties of PDMS crucial, as it is the main chemical polymer I will be using throughout my scientific research/experiment I conduct this year.

McKenna, C. (2015, December 2). How to remove plasma-bonded PDMS from glass? Retrieved December 5, 2016, from Royal Society of Chemistry website: http://blogs.rsc.org/chipsandtips/2015/12/02/how-to-remove-plasma-bonded-pdms-from-glass/

Summary: Online Article

Found off the Royal Society of Chemistry's website this **article** seeks to explain a procedure which can be used to remove PDMS from a glass surface easily with commonly available chemicals. The tip was discovered by Polish professors of physical chemistry Wojciech Adamiak and Martin Jönsson-Niedziolka. The method is advantageous because PDMS can be bonded and removed as many times as desired to the same glass surface. This method is useful for elctrochemical measurements, however is not limited to only that type of application. Simply, sulfuric acid is poured along the edges of the PDMS lens. Then, the PDMS is allowed to be in contact with the PDMS for several minutes, and finally removed with tweezers. Then, the glass is washed with water and can be reused as a surface from which PDMS is cured.

Applications to Research:

This discovery and information will be incredibly useful to me, as I was stumped for weeks over how to most effectively remove PDMS from the glass surface it was on without leaving uneven edges on the side of the PDMS in contact with glass. I finally have a method in which I can use concentrated sulfuric acid, which although corrosive, is still commonly accessible by many people and places. A glass pipette, a glass beaker, tweezers, water, and lab glasses are also materials needed. I expect to try this method for my next experiment to cure PDMS lens. I hope the method is effective, and with a solution to remove PDMS from glass effectively, I can move on to perfecting the optical properties of the PDMS itself.

Molla, C. (2012, April 25). *How to make PDMS* [Video file]. Retrieved from https://www.youtube.com/watch?v=zWQTnH79l_8

Summary: Online Video

Found on *Youtube*, this **video** serves to inform viewers on how to cure PDMS, or polydimethylsiloxane gel. The creator of the video, Molla, is also the narrator of the video. Molla first lists the materials needed in the process of creating PDMS. He uses a silicone elastomer, a hardener, also known as a curing agent, a pipette, a dessicator, and a scale. He first measures out a desired amount of silicone elastomer. He then measures out the appropriate amount of the curing agent he needs so that the mixture of a 10:1 ratio of silicone elastomer to curing agent. Using the pipette, Molla places a small amount of curing agent into the elastomer and finally mixes the elastomer and curing agent together using the tip of a pipette. Finally, he states to place the PDMS gel into a dessicator, and then the gel is hardened, or cured, in thirty minutes.

Applications to Research:

This video can be used in my research as a source for me to reflect on when actually curing PDMS myself in my experiment. I know there are several different methods that can be used to cure PDMS, and although the definite method I will use will be more clearly defined by my mentor at UMBC, I can look up various methods to get a better sense of what I will actually be doing. Honestly, I probably won't use this source in my actual research paper, but I can take from this video various terminology and techniques I may use in the final paper I have later. I will look for many different sources on curing PDMS so that I may come up with my own procedure to cure PDMS, or more specifically create spherical hanging droplet lens from PDMS, which I can potentially use in a microscope, which perhaps may be the *Foldscope*, the origami microscope which I have already learned about.

Optical properties of polymers. (n.d.). Retrieved from Intertek website: http://www.intertek.com/polymers/optical-properties/

Summary: Website

Found off the Intertek website, this informational **webpage article** seeks to inform readers about the various common optical properties that most all polymers share. There are many chemical, physical, and mechanical tests that polymers are subjected to in order to help the world understand the various optical properties a type of polymer may have as well as be affected by. Using fillers or additives, scientists can find the color measurement of a certain polymer. Using spectrophotometric data, scientists can discover the yellowness index. Gloss is the ability for the polymer to reflect light in a certain direction and can be measured from certain tests comparing various incidence angles. Haze is the ability for a polymer to disperse and scatter light from milky and cloudy particles a polymer consists of. A spectrophotometer is often used to find the amount of haze a polymer contains. Refractive index is the ability for the polymer lens to refract light through its particles. Additives, heat treatments, UV and visible light absorption are also used as methods to locate the refractive index of a substance. Finally, birefringence is used to identify stress on a polymer, as this property varies with refractive index. All of these properties vary with the various orientations of the polymer chains at the molecular level.

Applications to Research:
From the information provided by this article, I can perhaps use these properties or methodologies to measure various strengths and weaknesses of polymer lens. I can test to see which properties are the best expressed and which are weaker, and hence need to be enhanced. Also, this source may serve useful for the background research in the paper I write later.

Physical and chemical properties of silicone (polydimethylsiloxane) [Fact sheet]. (n.d.). Retrieved November 20, 2016, from Dow Corning website: http://www.dowcorning.com/content/discover/discoverchem/properties.aspx

Summary: Online Chemical Fact Sheet
Published online on the website of the chemical manufacturer Dow Corning this **webpage fact sheet** has a simple layout of the various chemical and physical properties of the siloxane monomer used in polydimethylsiloxane (PDMS). There are also nice diagrams that could perhaps be used to analyze the chemical composition and bonding structure of PDMS. PDMS has a polar inorganic backbone composed of silicone (Si) and oxygen (O), and nonpolar organic subgroups made of methyl groups or ($-CH_3$). The long Si-O bonds in the backbone as well as low barrier to rotation and wide bond angle allow PDMS to be a highly flexible and mobile polymer. The weakly bonded methyl groups, due to weaker intermolecular forces, can be easily substituted by other chemical subgroups durign polymerization, causing the polymer to perhaps become more rigid. Also, the Si-O backbone has a high bond energy of -445 KJ/mol, meaning PDMS is very strong and stable. Due to chemical and physical properties, PDMS can easily wet most surfaces, be a water repellant, and cause film to form (it can flow over itself). Because, PDMS is also very shear stable, it flows very easily and quickly. Also, PDMS is very temperature-resistant.

Applications to Research:
This fact sheet will be incredibly useful to my research and background knowledge of PDMS. Knowing the chemical structure and the various chemical and physical properties of PDMS will serve me well in knowing the background information neccessary for my research project as well as my internship this year.

Portable AFM images any surface. (1999, October). *R & D*, *1999*(81). Retrieved from Gale Virtual Reference Library database. (Accession No. GALE|A57231359)

Summary: Online Database Reference Source
From a magazine called *R & D*, and found on Gale Science in Context Database, this brief **article** is extremely short, containing a few main details. The atomic force microscope (AFM) newly created in Switzerland during the time is briefly described. The AMF solves the problem of trying to focus on an image of a sample which does not fit on the microscope stage or slide. With a non-oscillating quartz probe, the AFM scans any micron surface to sub-micron scale, clearly magnifying the image. The various dimensions of the microscope are provided. This microscope also connects to the computer so that analysis and tweaking of images can be simplified processes.

Applications to Research:
From reading this short source, I know I cannot get much factual information or statistics out, but this source contributes to my research project by helping me become more open-minded to other processes in the field of microscopy. Simply put, this source only discusses the functions and

uses of the Atomic Force Microscope from a consumer standpoint, but not all the technical mechanisms behind the working of the AMF. However, I may be able to integrate the main principle of this microscope, which is to remotely scan objects, and perhaps be able to add that feature into the final microscope I hopefully make at the end of my internship. Because I am making a tiny, cheap, portable microscope, most likely, some samples will not be able to fit on a slide, so I believe integrating the principle behind the AMF may improve this origami, light microscope. This source is also a great source to find other ideas and sources from, to make up for its extremely limited information.

Rack, P. D. (n.d.). Optical microscopy [Powerpoint slides]. Retrieved from http://web.utk.edu/~prack/MSE%20300/Lightmicroscopyhandout.pdf

Summary: Powerpoint Slide Lecture Notes

Discovered online as a PDF file, these **college lecture slide notes** deem to be useful for the audience, or student, who is interested in optics and microscopy but do not have advanced knowledge in the subject area. In other terms, the slide notes seem as though used as a visual aid for Professor Phillip D. Rack's college course at the University of Tennessee. The notes go through a broad range of topics that are essential to the knowledge and background regarding optical microscopy. For instance, a brief introduction is given on the history of the invention and development of the microscope as well as other optical lens. Then, the notes transition into basic optical properties and measurements: both the definitions, equations, and uses. Finally, the notes advance into more specific forms of microscopy present in the world today. Many types of microscopy as well as their specific uses are discussed throughout the latter portion of the powerpoint.

Applications to Research:

These college notes on optical microscopy will be helpful to my own background knowledge as well as research. It will also serve as a great source for background information in my research paper that I must write later. There is so much relevant information to my own project which I must study and comprehend so that I may conduct a good, highly-detailed research project as well as experiment. Also, I know that there are some information I do not need to know or focus on as much. However, knowing other forms of microscopy which exist can potentially enlighten my ideas on improving my project. With the information provided in the article, I'll be able to focus on measuring and calculating optical properties of my PDMS lens.

Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Jackson, R. B. (2011). Biologists use microscopes and the tools of biochemistry to study cells. In B. Wilbur, J. Frost, G. S. Jutson, B. N. Winickoff, P. Burner, S. Berge, . . . E. Gregg (Eds.), *Campbell biology* (9th, AP ed., pp. 94-97). San Francisco, CA: Pearson.

Summary: Print Reference Source

Found in the textbook of an advanced placement biology textbook, this **chapter subsection** provides a simple detailed introduction and overview of microscopy and optics. A brief history of the invention and innovation of the microscope is provided, followed by a brief description of the various types of microscopes used. The different types of microscopy are also compared and contrasted to allow a more comprehensive understanding for the audience. The most commonly used type of microscope is the light microscope, which too, has many subcategories of various imaging types. Three important parameters in microscopy are defined and discussed, as well as many common good microscope techniques, such as cell fractionation, which aims to take cells apart and separate major organelles and structures from one another.

Applications to Research:

This textbook subchapter would be a great source for me to further my knowledge on microscopy, from the biologist's perspective, and understand how it has helped biologists study the inside of a cell. Also, I am provided with definitions of various microscopy technical terms, so that I may better understand the scientific language involved in my research project, succinctly yet detailed enough.This source provides labeled diagrams, pictures, and charts. Also, the subsection is short, so I can find information on other microscopy specifics from more complex sources, and comprehend the language and terminology used. I expect to use this source as a bridge leading me to find better and more resourceful sources.

Scientific principles. (n.d.). Retrieved November 13, 2016, from Department of Materials Science and Engineering University of Illinois Urbana-Champaign website: http://matse1.matse.illinois.edu/polymers/prin.html

Summary: Website

Published online by the University of Illinois's Materials Science and Engineering Department, this **website article** discusses polymerization as well as other related terminology and processes. There are two main types of polymerization: chain-reaction polymerization and step-reaction (condensation) polymerization. With chain-reaction polymerization, monomers and a catalyst, often a free-radical peroxide, are needed. The process takes three steps: initiation, propagation, and termination. The reaction is exothermic and can happen rather quickly. Branches and cross-links may also form. In condensation polymerization, oligmers, short polymer chains, are formed, and the process is relatively slow. Often heat is required, no branching and cross-linking forms, and a by-product (water, HCl, etc) forms. Polymers can be linear, branched, or cross-linked. Homopolymers have one type of monomer and copolymers may have many, in configurations of random, block, graft, or alternating configuration. Polymers are either crystalline or amorphous, and as thermoplastics or thermosets. Five types of molding exist: injection molding, compression molding, transfer molding, blow molding, and extrusion.

Applications to Research:

This source will be useful to me as it provides background knowledge and information of polymers and how they are created, how they are structured, and various other information on the chemical composition of polymers in general. I can also try to figure out how curing PDMS could be analyzed in this perspective as a polymer. The background knowledge provided will be incredibly important for me to understand.

Vandervoort, K. (2014). Microscopy. In *The Gale encyclopedia of science* (5th ed.). Retrieved October 6, 2016, from http://ic.galegroup.com/ic/scic/ReferenceDetailsPage/

Summary: Online Database Reference Source

From an online database, this reference source **article** serves to inform viewers about the background on microscopy. Various types of microscopy are discussed, such as the light, electron, and scanning tunnel microscopy, as well as information on how each type works, such as how the image is formed, and through what means and precision. A history in the advancement of the microscope is given, so readers can be informed of how the microscope was invented and innovated to achieve its wide-range and specificity in uses today. Also, this source seeks to give many other aspects within microscopy, such as recent, uncommon developments and discoveries in the field.

Applications to Research:

This article would be a wonderful background source for my research paper. For instance, this source just explains the most important terminologies and concepts in microscopy in simple manners such as through real-life metaphors and other relatable ideas. Thus, I can reinforce my understanding, if not expand my knowledge on microscopy, and get a better sense of how to explain these scientific terms to perhaps an audience who is not so scientifically literate. Also, by reading this source, my creativity and room for new thoughts has been sparked, as the information under the subheading “Recent Developments in Microscopy,” seems to be extremely interesting and insightful. For instance, some types of microscopes involve reflecting sound waves off a specimen, and others involve using X-rays or atomic forces to study specimens. The biggest modern advance is probably the creation of an all-in-one super microscope that integrates many functions, such as imaging, organizing, drilling holes into specimens, etc.