# The Effects of White Distilled Vinegar and Bleach on the Individual Characteristics of Shoe Soles

Gwendolyn Sellers

Edited by: Ethan LaFon

**Abstract:** White distilled vinegar and bleach are two common cleaning products employed in the deep cleaning of household surfaces and objects. Many use these substances to wipe down commonly shared surfaces of germs and grime due to their cleaning strength. A similarity in these two substances is their proficiency in removing blood and blood stains from objects and clothing, being commonly utilized for this task. Therefore, if a crime scene had large amounts of blood, it could be concluded that white distilled vinegar and bleach could be likely useful in high quantities to clean the scene properly. Individual characteristics within shoe prints can be caused by wear and tear on the shoe sole, often made of rubber and other materials. It is generally advised to dilute white distilled vinegar and bleach for use in cleaning rubber household items due to the deterioration and weakening the two substances often cause within rubbers. White distilled vinegar due to its acidic nature, acetic acid, and bleach, sodium hypochlorite, as a caustic cleaner. It is often that shoe prints are employed as proof of a person's presence at the crime scene. However, this could be pushed further if shoe prints could be used as evidence to link a person to activities that occurred within the crime scene as well, specifically cleaning. With this information, it can be concluded that extended contact of shoe soles with white distilled vinegar and bleach will cause distinct individual characteristics on the soles that can be viewed when shoe printing.

*Keywords: vinegar, bleach, shoe printing, blood*

Forensic scientists often search for methods of detecting traces that surfaces may have been cleaned of blood or evidence. Luminol is an example of this, creating a luminescence reaction when coming into contact with oxidizing agents and peroxidases like traces of blood and bleach (Hesskew 1991). If heavy traces of white distilled vinegar or bleach are found at a crime scene, this could be useful in finding further evidence.

White distilled vinegar products vary from 4% to 7% acetic acid, which directly translates to their level of acidity (Johnston and Gaas, 2006). A rubber commonly found in shoes and especially boots is butyl rubber (Isobutylene-isoprene copolymer), a flexible and weather-hardy synthetic rubber (Industrial Rubber Goods). Adhesion properties can be weakened due to heavy exposure to both acidic and alkaline environments. In a study where samples of butyl rubber were exposed to varying pH properties, higher levels of acidic and

alkaline pH generated up to 60% fewer adhesion properties due to deterioration

Bleach must be handled carefully around rubber, a surplus applied to rubbers can cause the rubber to soften (Lv et al. 2022). As a substance, bleach is useful in cleaning and disinfecting surfaces. It consists of 3 to 8% sodium hypochlorite, similar to the acetic acid content within white distilled vinegar (Benzoni and Hatcher, 2022). The property being caustic marks it's harsher cleaning value, often wearing down other materials with prolonged exposure (North Carolina Consumers Council, 2022).

**Materials and Methods**

To conduct this experiment, one must first obtain three pairs of shoes with rubber-based soles, Great Value white distilled vinegar (*Walmart Inc., Bentonville, AR*), and Clorox bleach (*The Clorox Company, Oakland, CA)*. For each pairing, mark the left shoe for white distilled vinegar and the right shoe for bleach in a highly visible region. Gently clean all with warm water and allow to fully dry before proceeding. The shoes used in this specific experiment were a pair of women's running shoes (*ASICS*), women's wedge boots (*Lifestride*), and women's slides (*Xhilaration*) for examination of their rubber soles. Having a pair of running shoes with a rubber based sole will be significant as typically used footwear (ASIC).

within its internal structure (Khamani, Sadeghi, & Talebi, 2017).

Obtain two 10" by 15" cookie sheet baking pans and mark with white distilled vinegar and bleach respectively. Heavily avoid the mixing of white distilled vinegar and bleach as it can produce chlorine gas, keep the pans and marked shoes separate from one another and avoid any mixing (Washington State Department of Health). For each shoe involved shoe print using cooking oil, cocoa powder, shoes, and a paintbrush. Rub the sole of the shoe with a layer of cooking oil before pressing down on the center of a page of white printer paper. Clearly mark the page with the type of shoe, side, cleaning product to be used, and minutes soaked. Using the paintbrush, dab a small amount of cocoa powder over the wet regions of the paper so that the shoe print becomes visible. Gently blow away excess cocoa powder from the page. Document by taking an overhead, clear photo of the entirety of the page in a well-lit room. Repeat this process for all six shoes that will be experimented with until all six shoes have been printed, labeled, and documented. Once again clean all six shoes under warm water, remove all oils, and allow to fully dry. Fill one labeled baking sheet with a thin layer of white distilled vinegar until the cookie baking sheet is halfway

filled. Repeat this process using bleach in the second baking sheet until halfway filled. Set the three assigned shoes into the distilled white vinegar baking sheet and set a timer for thirty minutes. Once thirty minutes have elapsed, remove the shoes from the baking sheet and wash the soles of the shoes thoroughly with warm water. Once dry, repeat the shoe printing process. This time, add an addition of 'thirty minutes' onto each paper's label. Wash after each soak. Set the three shoes marked for white distilled vinegar back into the white distilled vinegar pan and set another timer for thirty minutes. After thirty minutes have elapsed, remove and repeat the process. Label the shoe print papers with 'one hour' and document once more. This process of soaking and shoe printing with thirty minutes and one hour in totality will be repeated using the clearly marked three bleach shoes in the bleach baking pan. Ensure that the marked shoes stay with their marked pans and do not mix. Nine shoe print pages each should be documented for white distilled vinegar and bleach.

**Results**

Overall, there were few prominent individual characteristics that can be observed from examining the results. It can be viewed on the softer foam-rubber materials of the slides, the middle region which had the most contact with the substances appeared to have less distinct marks within the shoe prints in both white distilled vinegar and bleach consistently. This can also be seen heavily along the sides as it moves towards the center section of the shoe (Fig. 5-6). Within ASIC women's tennis shoes in both white distilled vinegar and bleach, there were few noticeable differences that could be connected to the time soaked (Fig 1-2). It can be observed in Lifestride's women's boots in both substances that the grooves within the middle of the shoe become less distinct in each trial (Fig. 3-4).


**Fig. 1.** Shoe print results of ASIC woman's left tennis shoe without white distilled vinegar and with white distilled vinegar after thirty and sixty minutes.

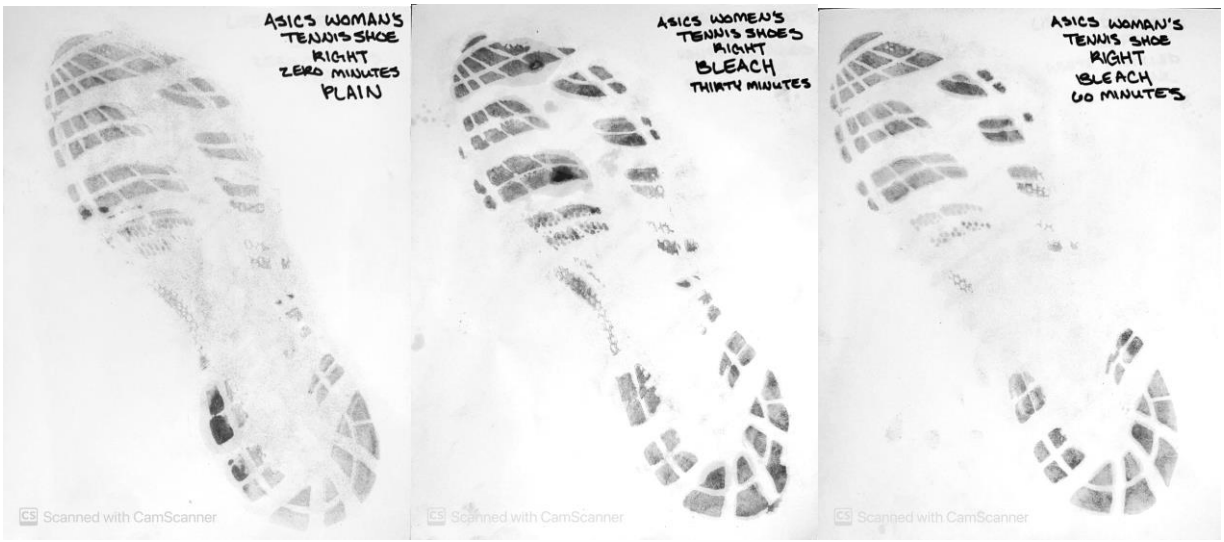


**Fig. 2.** Shoe print results of ASIC woman's right tennis shoe without bleach and with bleach after thirty and sixty minutes.


**Fig. 3.** Shoe print results of Lifestride women's left boot without white distilled vinegar and with white distilled vinegar after thirty and sixty minutes.


**Fig. 4.** Shoe print results of Lifestride woman's right boot without bleach and with bleach after thirty and sixty minutes.

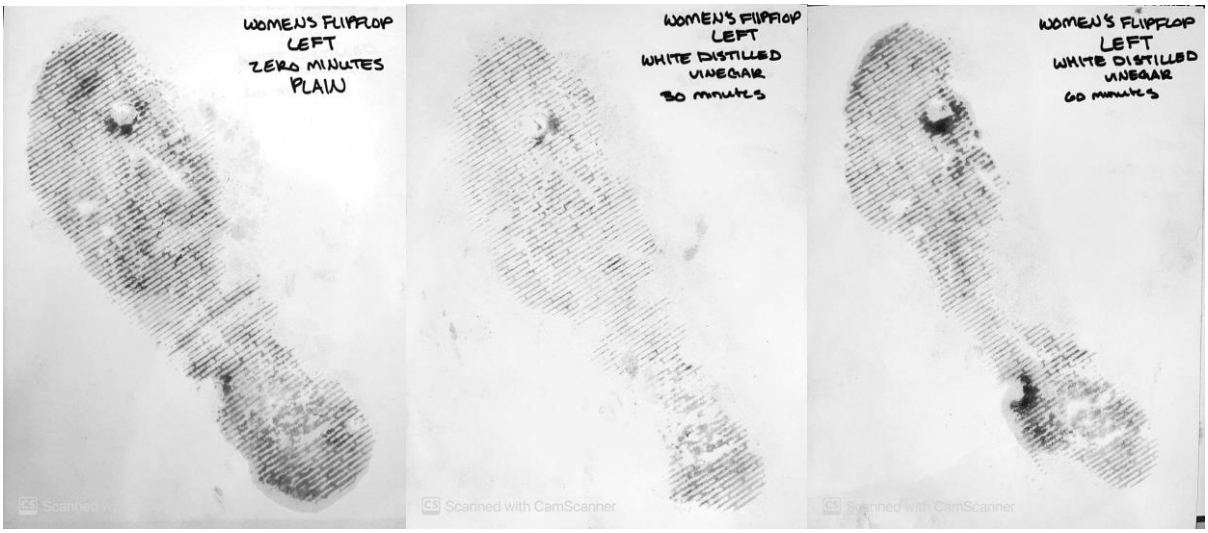


**Fig. 5.** Shoe print results of women's left slides without white distilled vinegar and with white distilled vinegar after thirty and sixty minutes.

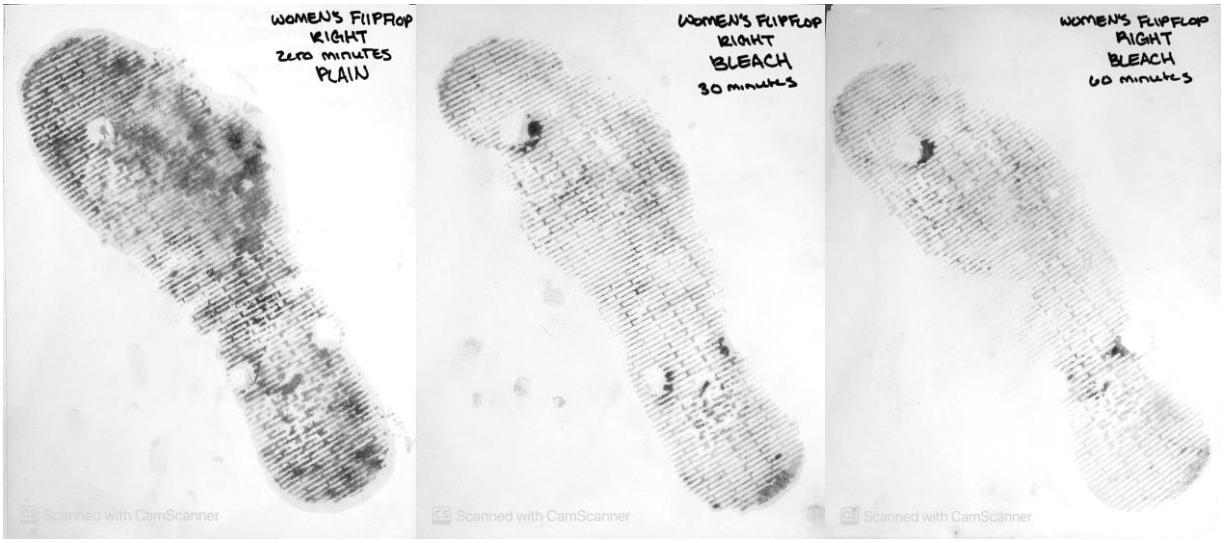


**Fig. 6.** Shoe print results of women's right slide without bleach and with bleach after thirty and sixty minutes.

**Discussion**

Rubber makes up 30% of shoes assembled worldwide, rubbers and more specifically synthetic rubbers significant in shoe sole production. Synthetic rubbers include thermoplastic rubbers (TPR) which are lightweight and durable but keep similar properties of elasticities to other rubbers. Along with this is a polyurethane (PU) that is commonly used and is a component that is rigid and heat resistant (Golubeva and Pogorelova, 2021).

Varying abilities to shoe print and different shoe printing techniques may contribute to the quality of prints for comparison. This can influence how many characteristics can be

tracked or noted when performing this experiment.

Being able to view distinct marks from extended time in contact with white distilled vinegar and bleach could lead to further experiments and knowledge in connecting clothing to crimes. This could include how quickly these products deteriorate and soften different types and amounts of rubber in distinct varieties of shoe soles. With such a large range of products that can be included in shoe sole making, this can be utilized to specifically target testing against certain materials. If strong conclusions can be produced about individual characteristics from chemicals within shoe soles, then this may help forensic scientists build further evidence from shoe prints into the future.

## Literature Cited


**ASICS, 2021.** How to Choose Running Shoes? https://www.asics.com/gb/en-gb/asics-advice/choosing-the-right-running-shoe-3-types-of-running-shoe-explained.html

**Benzoni, T. & Hatcher, J., 2022.** Bleach Toxicity. *National Library of Medicine*. https://www.ncbi.nlm.nih.gov/books/NBK441921/

**Golubeva, O. & Pogorelova, A., 2021.** Analysis of the quality of modern polymer materials of sole. *E3S Web of Conferences, 273,* 7. https://www.e3s-conferences.org/articles/e3sconf/abs/2021/49/e3sconf_interagromash2021_05002/e3sconf_interagromash2021_05002.html

**Hesskew, D., 1991.** Luminol. *Law and Order, 39,* 31-33. https://www.ojp.gov/ncjrs/virtual-library/abstracts/luminol

**Industrial Rubber Goods.** Butyl Rubber (IIR). http://www.industrialrubbergoods.com/butyl-rubber.html

J**ohnston, C. & Gaas, C., 2006.** Vinegar: Medicinal Uses and Antiglycemic Effect. *National Library of Medicine, 8(2),* 61. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1785201/

**Khamani, S., Sadeghi, G., Talebi, S., 2018.** Butyl Rubber-Aluminum Adhesion: The Effect of Acidic and Alkaline Environments on Adhesion Strength. *Journal of Polymers and the Environment, 26,* 989-998. https://link.springer.com/article/10.1007/s10924-017-1007-4#:~:text=Considering%20these%20usages%2C%20butyl%20rubber,rubber%20properties%20including%20adhesion%20strength.

**Lv, M., Fang, L., Yu, H., Rojruthai, P., Sakdapipanich, J. 2022.** Discoloration Mechanisms of Natural Rubber and Its Control. *National Library of Medicine, 14(4),* 764. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8875958/

**North Carolina Consumers Council, 2022.** Bleach Tablets Keep Your Toilet Bowl Clean but Usually Cause Costly Damage to Rubber Seals. https://www.ncconsumer.org/news-articles-eg/to-bleach-or-not-to-bleach-should-you-use-bleach-tablets-in-your-toilets.html

**Washington State Department of Health.** Dangers of Mixing Bleach with Cleaners. https://doh.wa.gov/community-and-environment/contaminants/bleach-mixing-dangers