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# Highlights: Reusing Masks, Face Covering Efficacy, Plant Restarts, and More

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## CAN N95 RESPIRATORS BE REUSED AFTER DISINFECTION? HOW MANY TIMES?

The arrival of the COVID-19 pandemic in the United States in early 2020 will long be remembered by the immediate shortage of personal protective equipment (PPE) for health care workers (HCW)—especially N95 respirators. By design, an N95 respirator must be capable of capturing 95% of airborne test particles (0.3 $\mu$m). The acute shortages of PPE during the onset of the pandemic left many HCW with the difficult choice of reusing a disposable N95 respirator or going unprotected. In the absence of an effective means to decontaminate N95 respirators, the risk of SARS-Cov-2 infection in HCW was a concern from the beginning. By the end of April, the Centers for Disease Control and Prevention (CDC) had recommended decontamination methods for N95 respirators.[1]

A recent publication by Liao et al. reported on five CDC recommended methods that were considered to be "user friendly" in hospitals and by the general public.[2] The key, as you might imagine, is to minimize the physical degradation of the filter material, yet inactivating any potential pathogens. As reported by the authors, the preferred treatment methods used to collect data involved dry heat under various temperatures, steam, 75% ethanol, chlorine solutions, and ultraviolet germicidal irradiation (UVGI). As per the report, it was concluded that applying dry heat, no greater than 100 with low relative humidity, and using UVGI treatment proved to not have caused major damage to the respirator and its performance. In general, the authors suggested avoiding decontamination methods that involved liquids and steam.

This article is useful to those interested in establishing treatment methods for decontamination and reuse of N95 respirators, when necessary.

In unprecedented times, reports like this provide additional evidence as to the purported efficacy of an emergency measure to protect health and safety.

**Luisiana Galindo and Michael B. Blayney**

## HOUSEHOLD MATERIALS SELECTION FOR HOMEMADE CLOTH FACE COVERINGS AND THEIR FILTRATION EFFICIENCY ENHANCEMENT WITH TRIBOELECTRIC CHARGING

Personal protective equipment (PPE)—especially respiratory protection—has been an essential component in combating the pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). While the majority of the PPE—particularly N95 respirators—has been reserved for healthcare workers and first responders, disposable face masks and face coverings are the expected norm for everyone today. Understanding the relative filtration efficiencies of commonly available materials for mask and face coverings is important.

In a recent article,[3] Zhao et al. investigated not only the filtration efficiency of various, commonly available household materials but also if the efficiency can be further increased with the induction of a static charge. Various materials were assayed for their filtration quality factor ($Q$) which considers both the filtration efficiency of the material and also the pressure drop across the material. Pressure drop is critical when assessing how comfortable the face covering will be to wear for longer periods of time.

Zhao et al. found that various cottons had high filtration efficiency, but the pressure drop across the fabric made the overall filtration quality factor somewhat lower. In contrast, spunbonded (unwoven) polypropylene had a high filtration quality factor in spite of a lower filtration efficiency due to a low pressure drop across the fabric. Spunbonded polypropylene was found to have a somewhat higher filtration efficiency when charged. Zhao et al. also found that the material could be triboelectrically charged by rubbing it with latex or nitrile rubber.

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Overall, this paper is useful for assessing the filtration efficiency of various materials and the effects of charging them. While the authors suggest that the fabric can be charged by the wearer's gloves prior to donning the fabric mask, this is not recommended from a biosafety perspective. Instead, if the wearer wishes to triboelectrically charge the fabric of the mask, it should only be done with a clean mask and a clean piece of latex or nitrile. Further, the authors note that the overall $Q$ value of the fabrics does not change when fabrics are layered. Accordingly, these data could be used to construct a face covering of multiple different fabrics to maximize filtration efficiency and reduce pressure drop for an overall high filtration quality factor: important factors to consider in coping with a global pandemic lasting sometime into the future.

**Robert Foreman**

## ■ AEROSOL FILTERING EFFICIENCY OF COMMON FABRICS USED IN RESPIRATORY CLOTH MASKS

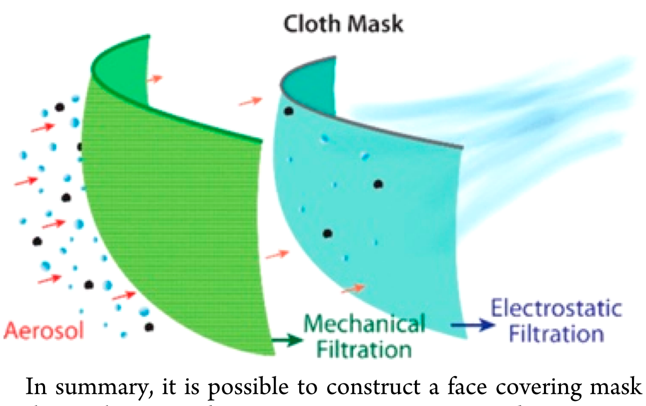
Disposable masks and N95s were in short supply when the COVID-19 pandemic reached the United States in early 2020. While the availability of these critical supplies has improved, they are largely reserved for Health Care Workers (HCW). Today, the CDC recommends that everyone wears some type of cloth face covering when out in public.

Unfortunately, there is not enough scientific data on the performance of common fabrics specifically the measurement of the filtration efficiencies as a function of aerosol size.[4]

A recent article by Konda et al. provides the results of measuring the filtration efficiencies of a number of common fabrics, as well as selective combinations for use as hybrid cloth masks, as a function of aerosol (sizes ranging from ~10 nm to 6 $\mu$m) covering a range of droplet sizes both large and small.[5] A disposable mask and N95 respirator were used for a relative comparison of effectiveness.[6]

Konda et al. reported that silk and chiffon are the most effective fabrics due to their electrostatic properties, which can exclude nanoscale aerosol particles. Fabrics with a tighter weave have higher filtration efficiencies. Cotton 600 thread per inch (TPI) filters out 90% for over 300 nm and over 65% for less 300 nm.

The combination of one-layer 600 TPI cotton with two layers of silk, two layers of chiffon, and one layer of flannel provided the greatest protection—exceeding 80% efficiency in the <300 nm range, and >90% in the >300 nm range possibly due to the combined effects of electrostatic and physical filtering. These results are comparable with standard N95 mask performance and even better for particles smaller than 300 nm.




In summary, it is possible to construct a face covering mask with equal or even better protection as compared to an N95 respirator against coronavirus. As a reminder to all, the mask must fit snugly as the filtration efficiency can drop by 50% if it fits poorly. Finally, proper cleaning, drying and storage are essential to ensure that the form of protection does not become a reservoir of dirt and germs. Since the Covid-19 pandemic will be with us for some time to come, having an understanding what materials are not (and are) effective is essential information.

**Marina Zelivyanskaya and Michael B. Blayney**

## ■ CHECKLIST FOR RESTARTING LABORATORIES ON COLLEGE AND UNIVERSITY CAMPUSES

The COVID-19 pandemic has impacted college and university campuses across our nation and around the world. Within a short period of time, many laboratories were shut down as students, faculty, and staff were required to leave their campuses to shelter-in-place at home. As administrations begin to consider how best to restart operations, there are many things that must be considered in bringing laboratories back into operation safely and protect all involved.

The Campus Safety Health and Environmental Management Association (CSHEMA) recognized the need for a comprehensive restart checklist, focused on laboratories in the higher education environment. Such a checklist would assist Environmental Health and Safety professionals as they in turn help their college and university departments restart work in laboratories. As their members began contributing to the CSHEMA body of knowledge in their community forum,[7] their Board of Trustees appointed a task force to bring all of these great resources together to create a much needed checklist.

The recently released checklist[8] is meant to assist higher education safety specialists as well as laboratory Principal Investigators (PIs) and other researchers in preparing to safely open and resume activity in laboratory spaces. Users will add, delete, and customize this checklist as needed to create a document that will best serve to ensure that their institution's spaces are prepared for research once again. Note that each institution may have various parties who handle different aspects of this checklist. Likewise, there may be some items specific to their institution, state, or local directives that warrant additions. This checklist could easily be converted to a matrix that assigns particular tasks to specific individuals, offices, or work units.

Members of the task force are as follows:

- Jeff Lewin, Chair, Michigan Technological University, Director of Chemical Laboratory Operations
- Kimi Brown, University of Pennsylvania, Sr. Lab Safety Specialist/Chemical Hygiene Officer
- Jesse Decker, University of Wisconsin Madison, College of Engineering Director for Safety
- Dr. Alissa Hanshew, The Pennsylvania State University, Laboratory and Research Safety Specialist
- Clarissa Lynch, University of Virginia, Chemical Safety Officer

**Jeff Lewin**

## ■ TO MASK OR NOT TO MASK

As institutions around the world are returning to operations, a major topic of conversation has centered around the specific policies and personal protective equipment required to return to the laboratory.[9−12] Of particular concern are the institutional policies requiring the use of facial masks as a part of the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"social distancing" guidelines for workplaces and educational environments. The use of cloth face masks is a community health practice as outlined by the World Health Organization (WHO)[13] and the Centers for Disease Control and Prevention (CDC).[14] The cloth face masks are personal protective equipment (PPE) as understood by the environmental safety community,[15] hence the questions and discussions relating to the use of masks in a laboratory environment, and particularly in teaching laboratories.

The Occupational Safety and Health Administration (OSHA) has released topic specific guidelines for COVID-19,[16] including frequently asked questions (FAQ) on cloth face coverings.[17] The OSHA FAQ has provided a response as to the key differences between the cloth face coverings, surgical masks, and respirators and has provided some guidance as to the applicability of the use of the cloth masks. However, the guidance does state "consistent with the CDC recommendation for all people to wear cloth face coverings when in public and around other people, if appropriate for the work environment and job tasks," and that there is "discretion to determine whether to allow employees to wear cloth face coverings in the workplaces based upon the specific circumstances present at the work site." It was also noted that in some cases "cloth face coverings could present or exacerbate a hazard." Thus, individual institutions are going to need to make a determination related to the specific environment and tasks to be completed.

In a teaching laboratory, numerous alternatives and suggestions have been posed, such as greater social distancing, use of shields, use of universal faceshields,[18] etc. The current discussion has yet and is not likely to identify a clear set of recommendations that can be utilized for every institution. Thus, each space and situation will need to be evaluated as individuals return to the laboratory.

**Frankie Wood-Black**

## ■ SAFELY WORKING WITH VACUUM GAS MANIFOLDS (AKA SCHLENK LINES)

A recent topic of discussion in the safety community has been about an update to the Schlenk Link Survival Guide.[19] The Schlenk line is a commonly used chemistry apparatus. It is a vacuum gas manifold developed by Wilhelm Schlenk[20] and is a dual manifold with one manifold connected to a source of purified inert gas, and the other connected to a vacuum pump. Schlenk line techniques are used for manipulating air and/or moisture sensitive compounds in organic and inorganic chemistry and biochemistry.[21] There are several physical and chemical hazards associated with this technique including the potential for pressure bursts, explosions, and implosions due to the use of vacuums, liquid nitrogen, and the chemicals involved.

Because of the hazards associated with this apparatus and its use, proper training and guidance is required. Andryj Borys had never used a Schlenk line prior to starting his Ph.D. work and found many others that were in a similar situation.[22] While looking for information as to the proper setup, use, and potential hazards, he found that many of the guides and resources were limited and were difficult to use, so he set out to develop a resource to help, the Schlenk Line Survival.[23]

Others have developed resources as well. Rob Toreki has an introduction to vacuum and Schlenk lines at the Glassware Gallery.[24] Another guide, Schlenk Line Design and Safety, was written by Patrick Frank while at the Stanford Synchrotron Radiation Lightsource (SLAC), Stanford University.[25] These are good places to start if you are new to using this type of apparatus.

**Frankie Wood-Black**

## ■ MEETINGS, SAFETY WORKSHOPS, AND NETWORKING OPPORTUNITIES

The American Chemical Society announced that it is moving its meeting to a virtual format. The "live" or synchronous portion of the meeting will be held August 17 through 20,[25] with more than 250 broadcast sessions. The Safety Pharmacology Society will also host its 2020 Annual Meeting, September 13 through 16 virtually.[26] The National Safety Council's (NSC) October meeting has been rescheduled to March 28 through 30 and moved to Houston.[27] Other meetings such as the ninth NANO Conference are still listed as in-person events.[28]

The Division of Chemical Health and Safety which normally holds in-person workshops during the National ACS meeting will be holding them online. Workshops planned include the Laboratory Safety Workshop, Blame Free Accident Investigation, Safety Leadership, Reactive Chemicals, Laboratory Waste Management, Cannabis Safety, and the Chemical Hygiene Officer Workshop.[29] The Laboratory Safety Institute has moved its offerings online as well.[30]

Because of the move to more virtual training, the Division of Chemical Health and Safety has also begun to host virtual networking opportunities.[31] Recent topics for these discussions have been laboratory restart protocols and social distancing topics.

**Frankie Wood-Black**

## ■ INCIDENT AND NEAR MISS WHEN CHEMICAL PLANT RESUMES OPERATIONS AFTER SHUTDOWN PERIOD

As chemical reactions are scaled, concerns of laboratory safety evolve into process safety. A useful collection of chemical process safety case studies is presented by the Center of Chemical Process Safety (CCPS) in the monthly Process Safety Beacon (PSB).[32] In relation to efforts to return to normal operations amidst the COVID-19 crisis, a recent edition of the PSB presented a case of an accident and near miss resulting from a plant starting up after shutdown.[33] The incident involved a mist separator, and two of its connections: (i) a forward connection to a pressurizing pump, and (ii) a downward connection to a water drain. When the equipment was restarted, the inner workings of the connected pump stopped suddenly and exploded, releasing potentially dangerous fragments into the casing of the pump. It was speculated in the PSB report that, had the pump fragments been ejected from the casing, anyone nearby could have been seriously injured.

The PSB report went on to summarize immediate and root causes of the pump explosion incident. At the time of system shutdown, the equipment was cleaned and drained of water. However, dust particles collected in the separator, over time, stuck open a valve on the drain. When the system was started up, the forward connected pump pulled air through the drain that was supposed to be sealed. This air, in turn, carried precipitated water collected in the mist separator all the way forward into the pump itself. The adventitious water caused parts of the pump to violently sheer and ultimately explode.


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While the immediate hazard was presented in the pump shrapnel captured by the pump casing, the root cause of the incident was the dust captured in the valve that allowed air into the system. This April 2020 entry in the PSB concluded with a series of notes stressing the importance that manufacturing and plant staff must ensure they are fully aware of safety critical equipment (SCE).

**Marc Reid**

## FAILURE OF A SUCTION PIPE CAUSES MASSIVE AMMONIA RELEASE AND INJURIES AT REFRIGERATION SITE

As well as the aforementioned pedagogic case studies in the Process Safety Beacon, CCPS also produces an archive of specific process safety incident reports.[34] One recent log presented another example of safety concerns caused by restarting plant operations after a period of shutdown. In 2010, there was a leak of approximately 32 000 pounds (nearly 15 metric tonnes) of ammonia gas from the Millard Refrigerated Services facility in Theodore, Alabama.[35] The leak occurred during the restart of operations. When the ammonia refrigeration system was restarted, there was a sudden deceleration of liquid in a roof-mounted suction pipe. The pipe catastrophically ruptured due to the resulting hydraulic shock (known colloquially as a "fluid hammer").[36,37]

The massive ammonia leak traveled 0.25 miles (0.4 km) downwind of the facility to where, coincidentally, over 800 contractors were helping clear up the aftermath of another process safety disaster, namely, the Deep Water Horizon oil spill.[38] In total, 152 people were treated for injuries related to ammonia exposure.[35] According to the United States Department of Justice,[39] the offending company was fined $3 million, owing primarily to a failure to mitigate the highlighted risk of hydraulic shock in ammonia-containing pipework.

**Marc Reid**

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