The Saga of the Universal Anti-COVID Facemask: Where Things Stand

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Questions? Comments? Anything left out? Anything you disagree with? I'd love to hear your thoughts. Email me at gjgraham4health@protonmail.com.

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We need an effective, inexpensive anti-COVID facemask made from materials that are abundant worldwide. Fortunately, we may have such a facemask. Here is what has—and has not—been accomplished.

The problem

Around the world, some 5.4 million people have died from COVID-19. In addition, many people who avoided COVID died anyway because overwhelmed healthcare systems could not cope with other deadly illnesses such as heart disease and cancer. Added to this were deaths caused by unexpected poverty and despair, a result of trillions of dollars in lost economic output. Further, many people who survived COVID-19 suffered permanent damage to their health.

Humanity is now much more able to cope with COVID-19 than it was at the start of the pandemic. Many people have acquired immunity to COVID from previous infection and we have new tools to fight the disease: vaccines, monoclonal antibodies, dexamethasone, remdesivir, anticoagulants, and molnupiravir. On the other hand, many people, worldwide, have not yet been vaccinated and lack good medical care. Disturbingly many people refuse vaccination. Worse, our best tools—vaccines, monoclonal antibodies and, to some extent, natural immunity—may not stop new COVID variants. Despite widespread optimism that the pandemic is abating, many people will die from COVID-19 this winter, and we may again face heavy economic losses due to COVID-necessitated lockdowns.

One partial solution

Facemasks are a low-cost, low-tech supplement to good medical care. At least one reputable study shows that surgical masks provide modest protection against COVID transmission. However, in contrast to the very fruitful (and expensive!) effort to develop anti-COVID vaccines and drugs, there has been almost no serious effort to develop better facemasks.

Almost all cigarette filters consist mainly of cellulose acetate. These filters can remove contaminants from inhaled air while not impeding that air even when the filters are squeezed. Thus, cigarette filters are plausible candidates to immobilize respiratory droplets or their contents. Tests of this idea are described below.

Cigarette filters are common. According to Sarah Lazarus of CNN, about 6 trillion cigarettes are manufactured each year, of which more than 90% include filters. Moreover, in 2015 there were 126 countries where at least 5% of the population smoked and 50 countries where at least 25% of the population smoked. Hence, cigarette filters are widely available and most of the world's people could probably acquire the 40-or-so (37.5 is the absolute minimum) cigarette filters needed to construct a facemask of the type discussed here (the "Bug-Eye" Facemask). In addition, cigarette filters that are not parts of cigarettes can be bought for about 2 cents each.

If cigarette filters protect against COVID, they will probably protect against all respiratory pathogens. This is because the trapping of respiratory droplets or naked pathogens will depend on the basic chemical and physical properties of the cellulose acetate used. This differs from immunological defenses such as vaccines and monoclonal antibodies, which new COVID variants may evade and which other respiratory pathogens are certain to evade.

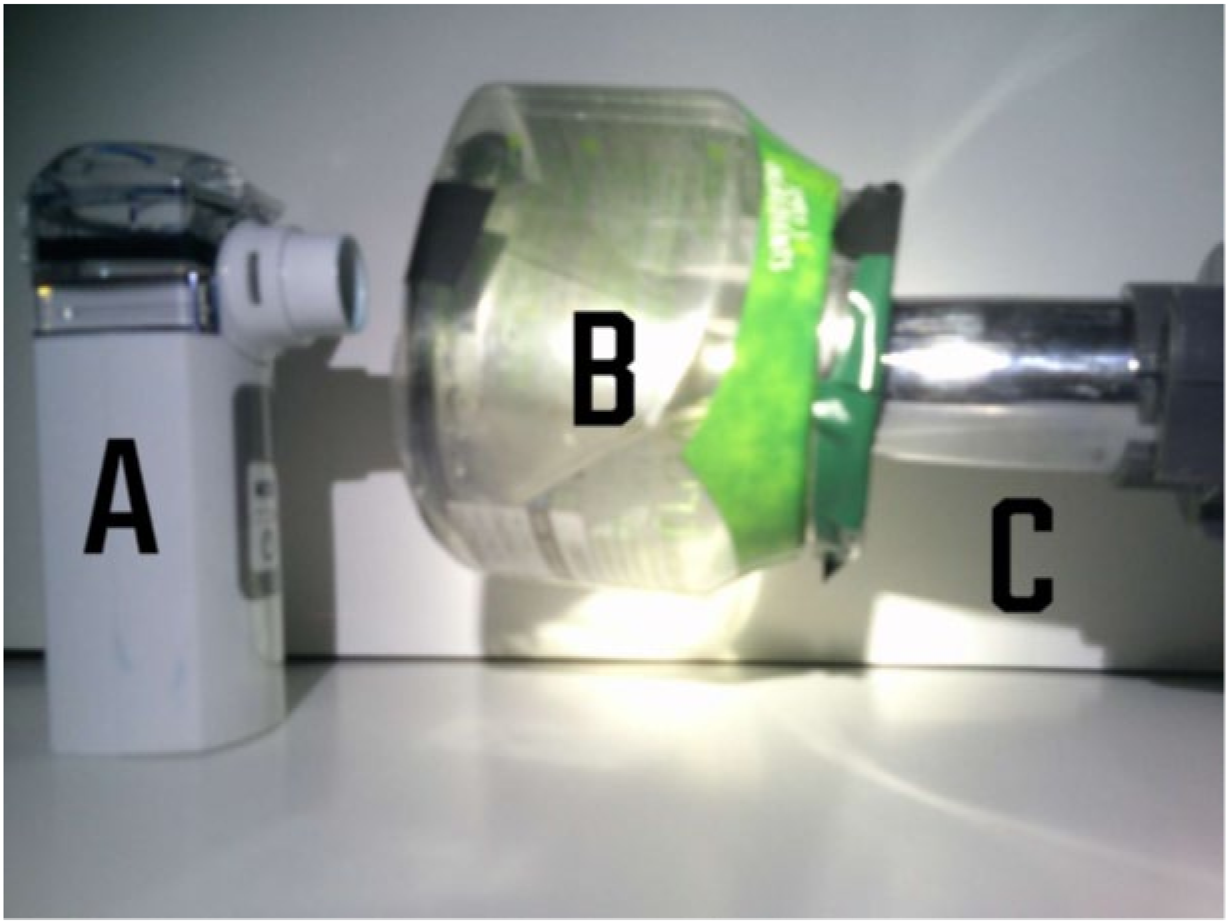
Can cigarette filters immobilize respiratory droplets?

To go forward, I need proof that cigarette filters can immobilize SARS-CoV-2 viruses carried by respiratory droplets. However, as of now, I have such proof only for surrogate aerosol droplets of the same size as infective respiratory droplets.

The surrogate droplets were created by a medical nebulizer. Some medicines are delivered directly to a patient's lungs via nebulization. Nebulization transforms a liquid medicine into an aerosol that can be inhaled. I used one brand of nebulizer, the Mesh nebulizer, to create an aerosol whose droplets ranged from 2 to 20 micrometers in diameter, with a peak at 4 to 5 micrometers (according to the Mesh product literature).

The aerosol consisted of commercial liquid blue food color to which a small amount of sodium chloride was added. (The sodium chloride was required for the nebulization process.) The purpose of the food color was to allow tracking of the aerosol droplets.

I tested the ability of cellulose acetate filters to trap aerosolized droplets using a Mesh nebulizer filled with food color (as noted above), a filter assembly (described below) and a household vacuum cleaner. These are components A, B, and C, respectively, in the photograph below.



In the above photograph, a Mesh nebulizer (A) is positioned to send a nebulized aerosol toward a filter assembly (B), which has air drawn through it by a household vacuum cleaner (C). The purpose is to test the degree to which the cigarette filter in the filter assembly will immobilize the aerosol.

The nebulizer produced blue droplets that entered the filter assembly and were then sucked toward the household vacuum cleaner. The test was to determine whether the blue color would be trapped by the cellulose acetate and prevented from entering the vacuum cleaner. The filter assembly is shown in the photograph below:

(Above) The filter assembly (Item B in the previous picture) shown disassembled. To the extreme left is a cigarette filter of the type that will be tested in the filter assembly. Second from the left is a similar cigarette filter that has been wrapped with vinyl electrical tape so that it will fit snuggly into the funnel, which is the third item from the left. Only the wrapped filter was inserted into the funnel; the unwrapped filter was not. The fourth item from the left is a wire screen that restrains the filter and prevents it from being sucked into the vacuum cleaner. The far side of the wire screen (not visible) has been modified so that it fits over the end of the vacuum cleaner used and forms a tight seal. The rectangular piece of masking tape which is on the front of the wire screen, and which has a hole in its center, is a guide to anchor the stem of the funnel. On the extreme right is a plastic container that houses the filter assembly. When operating, the arrangement is made airtight with vinyl electrical tape so that air enters the filter assembly only through the wrapped filter.

These experiments showed that the blue food color remained at or very near the point at which it first contacted the cellulose acetate filter. Red, yellow, and green food coloring behaved the same way, which is important because the food colorings are chemically different.

My hope, of course, is that COVID viruses that enter the cellulose acetate filters will also be immobilized. This could happen if the virus particles directly bind the cellulose acetate or if the respiratory droplets remain intact and bind the cellulose acetate. However, as noted above, this idea must be tested for this project to proceed but has not been.

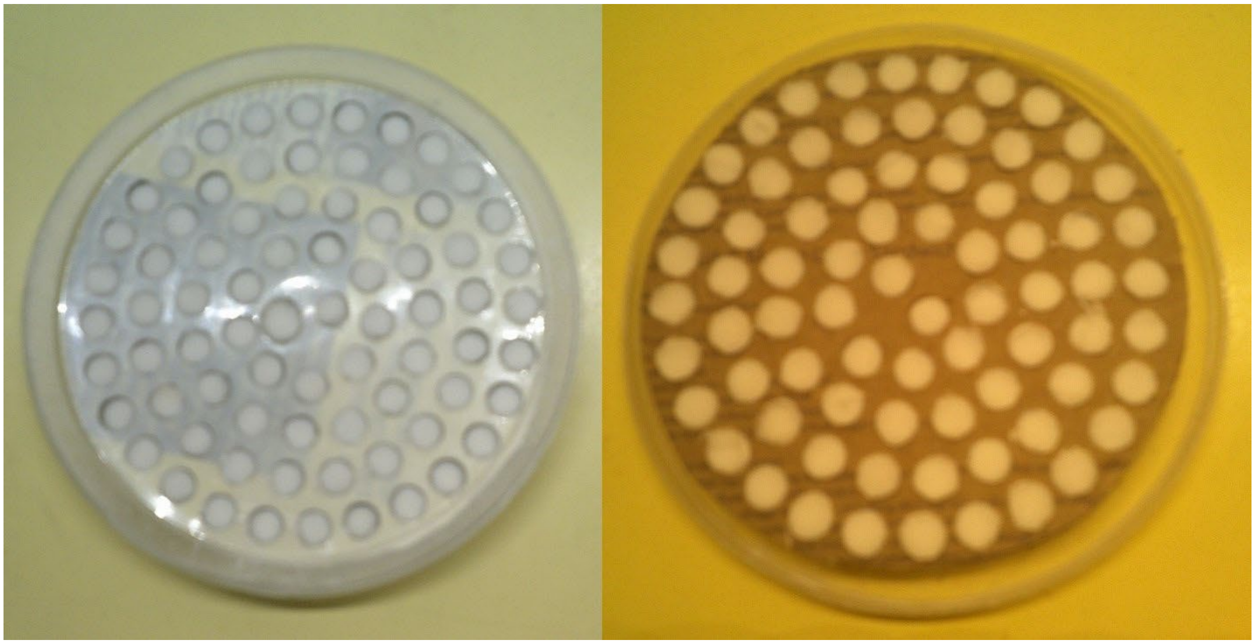
How can cigarette filters be used to purify air?

The amount of air that can be drawn through a single cigarette filter is too little to sustain a person. Because of this, we must direct air intake through many separate filters, arranged in parallel.

The Bug-Eye Facemask uses an array of 75 cigarette filters, each filter shortened to about half of its original length, to filter inhaled air. Since the resistance of a filter to the passage of air increases in proportion to the filter's length, an array of 75 half-length filters should allow 150 times as much air to pass through as would a single full-length filter. This, as it turns out, is enough air to allow a mask wearer to breathe comfortably.

The best material to construct the array from is non-corrugated cardboard of the type used in cereal boxes, along with 2-sided carpet tape. However, as discussed below, other materials can substitute.

The filter array is fastened to the lid of a food container that will attach the filter array to the air space of the mask. The two pictures below show a filter array seen from the outer (front) side and the inner (back) side.



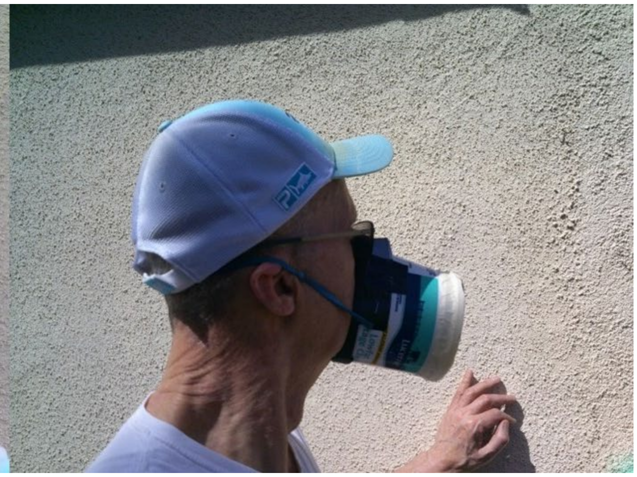
(Above) The photograph on the left shows a filter array seen from what would be the front of the facemask. The photograph on the right shows that same filter array seen from what would be the inside of the facemask. In both photographs, the filter array is attached to the lid of a food container.

The remainder of the Bug-Eye Facemask

The facemask also needs the following: an airspace, padding to form a comfortable and tight junction between the airspace and the wearer’s face, a restraint to prevent any filters that might be dislodged from choking the wearer, a mold to shape the airspace to accommodate the wearer’s nose, and an elastic strap to hold the facemask against the wearer’s face.

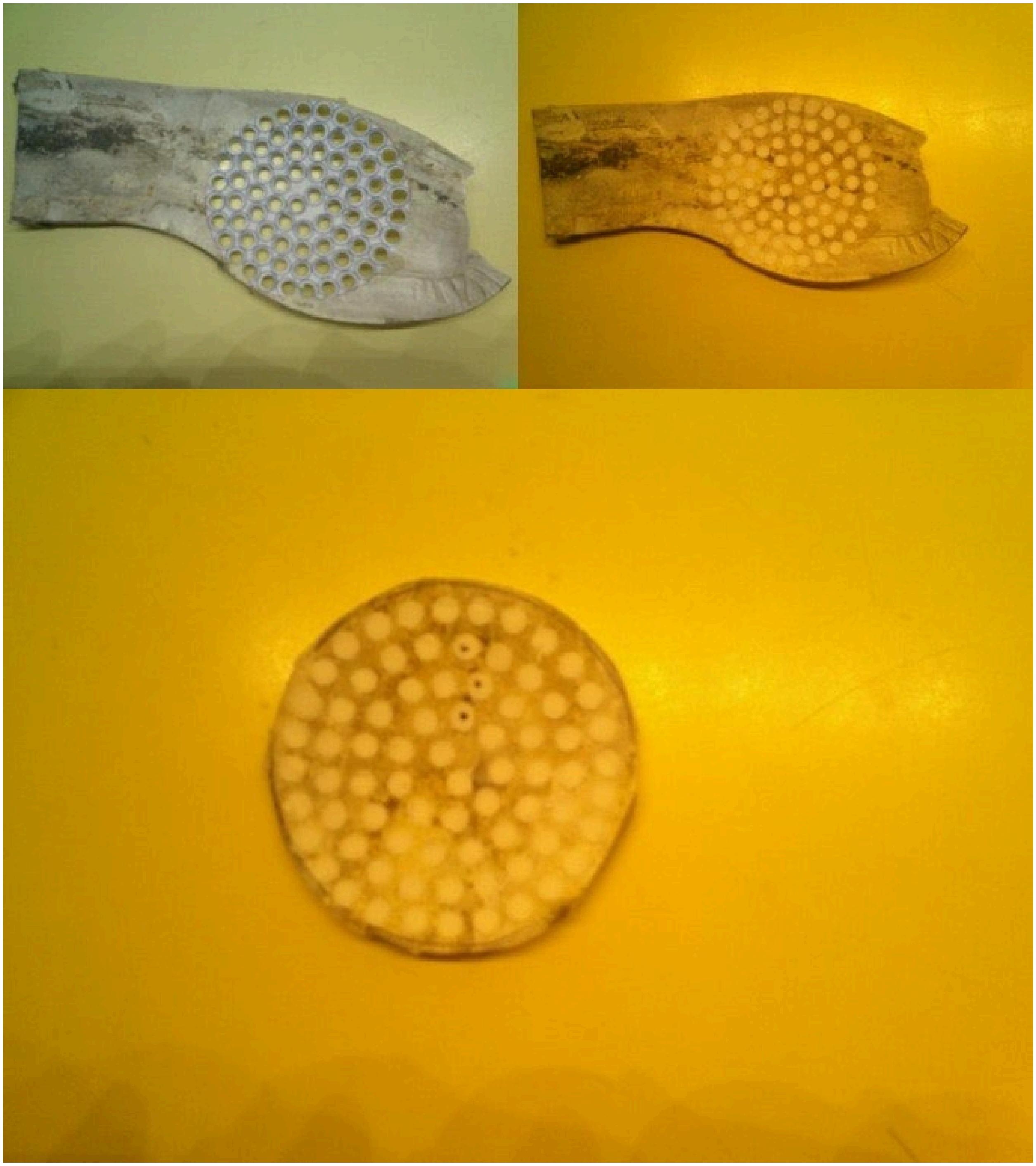
Most of the necessary components are widely available and cheap. The airspace is derived from a plastic food container, and the padding is weather stripping. The filter restraint is cut from a nylon scouring pad, the nose mold is made from L-braces or empty cans, and the elastic strap is made from large paper clips and rubber bands.

The two pictures below show me wearing a facemask prototype.

Multiple options

A longer report describing Bug-Eye facemask construction in great detail is available at this website . The longer report describes alternatives in case desired materials and tools are unavailable. If 2-sided carpet tape is unavailable to create a filter matrix, any of 3 types of glue might replace it. If non-corrugated cardboard or a long-reach paper punch of the right size cannot be found, silicone rubber and a cork borer might suffice. If neither cardboard or silicone rubber is available, it may be possible to use the sole on an old tennis shoe, as the following series of three photographs illustrates:



The above three photographs show stages in the construction of a facemask filter matrix from a rubber insert from the sole of an old tennis shoe. The photo at the upper left shows holes bored in the rubber by a cork borer. The photo at the upper right shows those holes plugged with truncated cigarette

filters. The photo at the bottom shows the circular array excised from the remainder of the rubber insert.

In order to shape the nosepiece of the facemask, the mask maker can melt and shape the plastic of the airspace with a candle, or reshape the plastic with an L-brace, an empty can of tuna, an empty sardine tin, or an empty can of soda pop. If weather stripping is not available to pad the airspace edges, a rolled-up paper towel wrapped in duct tape can replace it. If a nylon scouring pad is not available to prevent possible loose filters from choking the mask wearer, a patch cut from a furnace pre-filter might substitute for it, and so might a stiff wire screen. If a large paper clip is not available to anchor the rubber bands of the holding strap, a squeeze fastener can be used instead—and so can an office stapler.

The Next Steps in Facemask Construction

One issue remains to be addressed: what to do with exhaled air. In facemasks that I have worn, air enters the mask through the mask material but exhaled air leaves around the edges of the mask, thereby fogging the wearer's eyeglasses. Given that water-soaked filters lose their ability to trap aerosolized food color (see p.19 of the report) and that exhaled human breath is moisture-laden, it is probably better that exhaled air not pass through the cigarette filters and not be discharged upwards toward the wearer's eyes.

One-way air valves suitable for use in an aquarium are commonly available and cheap. However, it is not clear whether such valves would keep all SARS-CoV-2 viruses out of the facemask. If they do not, better one-way valves can probably be devised.

Obviously, the improvised construction methods described here and in the larger report are suitable only for emergency use. For non-emergency use, a manufactured Bug-Eye Facemask might be made entirely of stamped plastic, except for padding where the mask would contact a human face, and except for the filters. Truncated filters could then be inserted into wells in front of the mask. Use of stamped plastic would allow the filters to be spaced more tightly together, increasing the number of filters that could be used and thus allowing more filtered air into the facemask.

Cellulose acetate is sold wholesale in large blocks and by the metric ton. It may be that large patches, with dimensions of perhaps 10cm X 5 cm X 1 cm could replace the 75 cigarette filter segments used in a filter matrix of the type discussed here. Inhaled air could be filtered through 50 cm2 of cellulose acetate, which exceeds the cross-sectional area of 75 cigarette filters (about 38 cm2). Whether this would be possible would depend mainly on whether the patch of cellulose acetate could be mounted in a way that prevented it from cracking.

Even a facemask whose filtering material traps 100% of incoming viruses will fail if the mask does not fit the wearer perfectly and air enters around the edge of the mask. This is the main reason that facemasks fail, and more must be done to ensure that Bug-Eye Facemasks do not fail for that reason.

Steps Toward Facemask Adoption

The time has come to solicit feedback from the public. Readers of this article may know of ways to promote the development and adoption of this facemask or of obstacles that I have not considered.

The next scientific step is to learn with certainty whether cigarette filter cellulose acetate will stop SARS-CoV-2 carried by respiratory droplets. If cellulose acetate does not stop the virus, there is no point in continuing.

The logical people to enlist to settle this issue are university researchers, but I hesitate to do this because universities typically insist on patenting valuable ideas that they contribute to. If the mask is made available to people worldwide it should be as cheap as possible. It might be better to hire a professional sterility testing company.

If cigarette filter cellulose acetate can reliably remove respiratory pathogens from inhaled air, any other shortcomings of the facemask can probably be solved. Even if the filter matrices (which hold the filters) I have devised so far are inadequate, adequate ones can surely be devised. Even if the mask frame I have devised lets unfiltered air into the facemask, an adequate frame can surely be devised.

Beyond this, I want to:

1. Make the plans for a do-it-yourself Bug-Eye Facemask available to all who might benefit from it this coming winter (in the Northern Hemisphere).

2. Avoid legal liability for any shortcomings of the facemask and from any failure to comply with laws regulating medical devices.

3. Engage regulatory agencies as actively as possible

4. Persuade qualified manufacturers to make and distribute the facemask and to take on the burden of ensuring that what they produce is safe and legal.

5. To improve the Bug-Eye Facemask so that it becomes as effective, simple, and cheap as possible, and to push to make it available to all who would benefit from it anywhere in the world.

I need advice from people familiar with the Food and Drug Administration and its foreign counterparts, about legally acceptable ways to promote new medical devices (if the cigarette filter facemask is ruled to be a medical device) about publicity, about government or private small grants to cover expenses for this sort of thing, about grades of commercial cellulose acetate, and so on.

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(Updated December 24, 2021 and July 14, 2022)

Addendum on January 23, 2023

The cellulose acetate of cigarette filters is not hygroscopic enough to become wet from moisture in the air, but it is highly wettable. If a cigarette filter is held vertically over a container of water and one end of the touched to the surface of the water, water will travel up the cigarette filter and soak the entire filter within a second or two. The same will happen if the water is replaced by commercial liquid blue food coloring. Hence, it seems likely that the filters will remove water from respiratory droplets that enter the filters. The remaining liquid in the droplets might bind both the solids in the droplets and the cellulose acetate of the filters, thus immobilizing the droplets.