

Can plastic waste management be a novel solution in combating the novel Coronavirus (COVID-19)? A short research note

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Sultan Majed Al-Salem¹ , Mohammed Sherif El-Eskandarani¹
and Achilleas Constantinou^{2,3,4}

Abstract

The year 2020 has been noted to be one of major calamity the world over, in which the majority of efforts in research and development have been dedicated towards combating the threat of the novel Coronavirus (COVID-19). Ever since the announcement of COVID-19 as a pandemic, such efforts were dedicated towards the research of its spread and vaccination. Yet still, the world might reach a resolution via an environmental solution that various entities have overlooked, with a plethora of environmental benefits vis-à-vis waste management. In this short communication, the possibility of using plastic solid waste as a substrate to employ copper, and copper alloys and their nanocomposite nanopowders to be used as permanent surface protective coats, is presented. The fact that we present such materials to be of waste origin, is an added value advantage to their beneficial advantage of developing various commodities and products that could be used in our daily lives. Furthermore, the fact that such recyclable materials are susceptible to antiviral properties and chemicals, is an added value that we should not neglect.

Keywords

COVID-19, plastic waste, solid waste, antiviral, nanopowder

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Background

Towards the end of 2019, a novel Coronavirus which was later termed as COVID-19, has started to spread the world over with a clear exponential growth rate throughout population clusters within the Far-East moving towards the rest of the world. COVID-19 started in Wuhan, People's Republic of China (PRC), and was later identified as a type of pneumonia-causing virus that started to claim lives due to its severity and acute symptoms (Tian et al., 2020). As of 11 March 2020 (the time of initial draft write-up of this communication), COVID-19 has claimed the lives of 4292 globally with 118,322 confirmed cases including 80,955 cases in the PRC alone (World Health Organization, 2020a). On the very same date, the World Health Organization has declared COVID-19 to be a global pandemic (World Health Organization, 2020b). The virus has claimed over 584,556 lives with a confirmed number of cases surpassing 15.5 million till mid-July 2020. The outbreak is still considered to be ongoing and has caused more financial and global health concerns in comparison to the other two Coronaviruses: the severe acute respiratory syndrome coronavirus (SARS-CoV); and the Middle East respiratory syndrome coronavirus (MERS) (Bogoch et al., 2020). These concerns were escalated further when various governments (including the PRC's) adopted extreme measures in banning public traffic within city-centres, social gatherings, festivals and inbound/outbound transport services (Wu et al., 2020). The

forementioned events have contributed greatly to the global panic faced by many developed and developing countries alike, especially when considering the fact that COVID-19 was characterized with a short serial interval (e.g. five days) of symptoms with high mortality rate unlike the other two Coronaviruses (Lin et al., 2020). We therefore aim to present a short research note that proposes a novel idea where a material is compounded and coated from plastic solid waste (PSW) and coated with nanopowders that could also be originating from solid waste (SW) sources, and used as an antiviral surface against COVID-19. We also discuss the available literature on the concept, considering how scant it is, with an aim of presenting an idea that could be affectively used in the healthcare facilities sector among other applications (e.g. transportation, commercial goods, etc.). By that, transportation of viruses via touch and contact with commercial goods is minimized to a great extent, which is the main route of viral transfer among the residential clusters.

¹Kuwait Institute for Scientific Research (KISR), Kuwait

²London South Bank University, UK

³University College London (UCL), UK

⁴Department of Chemical Engineering, Cyprus University of Technology, Cyprus

Corresponding author:

Sultan Majed Al-Salem, Kuwait Institute for Scientific Research (KISR), PO Box 24885, Safat, 13109, Kuwait.
Email: ssalem@kISR.edu.kw

Current research trends

Understandably, an increasing interest has been noted, as of late, in COVID-19 research works. Various research institutes and academic bodies, notably within the PRC, have started boosting their research efforts in the field of developing vaccines, and taking those trials to field by introducing the human element. Outside the PRC, the United States alone has signed off an US\$8.3 billion research fund to take human trials to the next level, courtesy of the Centers for Disease Control and Prevention (Jacobson and Haynes, 2020). A simple literature search using the keyword “Coronavirus” on the database ScienceDirect® returns 14,010 results with a vast number of research articles (6211) as of 11 March 2020. The total number of results slims down to 699 search hits for the year 2020. Using the same keyword on Google Scholar® and SCOPUS® results in 163,000 and 18,543 search results, respectively, which also narrows down to 3430 and 429 for the year 2020 with respect to each database. Narrowing down the search to a more related search strategy using the keyword “COVID-19” shows a total search result in ScienceDirect®, Google Scholar® and SCOPUS®, of 257, 1,310 and 62 research related works as of the year 2020, respectively. Other than vaccine-related works and medication pertaining to the case at hand, there seems to be an understandable surge in research work related to the basic understanding of both virus strains (e.g. *L* and *S* Coronavirus strains), characterization and infection routes of COVID-19 (Cheng et al., 2020; Huang et al., 2020; Kucharski et al., 2020; Tian et al., 2020), and understanding the spread and distribution (including forecasting) of this virus (Chan et al., 2020; Wang and Zhang, 2020). Our simple literature search cites some of the literature but certainly not a bulk of it, since it falls out of the scope of this communication.

Substrates comprising waste plastics for antiviral surfaces

The world has been combating the problem of SW accumulation, and namely PSW, for the past few decades. Plastics have replaced almost all materials used in every known application, including the medical field, due to various reasons, namely their flexibility, versatility and high hygienic properties used in food industries and certainly medical applications (Ripolles-Avila et al., 2019). The increasing use of such products will inevitably increase PSW due to mismanaged waste components and lack of infrastructures in various regions of the world. To date, the total PSW produced on a global scale in accordance with World Bank statistics is estimated at 242 million metric tonnes per annum (Kaza et al., 2018). The hierarchy to treat and manage PSW streams is also well-known and has been researched extensively in the past, including the impact of recycling and heating loops, and degradation/environmental exposure of plastics in relation to impact on their integrity (Al-Salem et al., 2016, 2017; Hopewell et al., 2009). It is our belief that we have to start introducing an

important concept that has the potential to be viable on two fronts: the environmental management of waste components, namely PSW; and the medical application field of having an antiviral surface that originates from waste.

The use of plastics, namely those that are susceptible to heat and recycling treatment (thermoplastics), as surfaces for antiviral agents is not something that is exactly new. The use of thermoplastics as substrates for antiviral (and even antimicrobial) surfaces follows suit to past works on development of antimicrobial binding agents for paper (Sonenberg, 2005), antimicrobial and antiviral cottons (Schwarze et al., 1989), and fabrics (Harvey et al., 1982). Yao (2003) has developed (subsequently patented) a substrate of thermoplastic which could be polyethylene based among other types of polymers, that is suitable as an antiviral surface. Preferred antiviral or antimicrobial agents incorporated were 2,4,4'-trichloro-2'-hydroxy-diphenyl ether, 3-(4-chlorophenyl)-1-(3,4-dichlorophenyl) urea, silver ions, and salts and mixtures thereof. In an earlier attempt, Snyder Jr. (1999) developed a method for imparting anti-pathogenic properties on substrates as the coat was effective to be versatile and used in various fields. The recent COVID-19 outbreak has also revived work on chloroquine as a new antiviral agent originating from quinine compound which is naturally abundant in *Cinchona* trees (Devaux et al., 2020; Touret and de Lamballerie, 2020). Past experiences with chloroquine showed various success stories as a drug of choice against other types of Coronavirus, influenza types A and B, and human immunodeficiency viruses (Boelaert et al., 2001; Ooi et al., 2006; Paton et al., 2011; Savarino et al., 2003). With the exception of cellulose-based filters, chloroquine has proven high in sorption rate and sorption kinetics which shows great potential for developing it further as a drug of choice for antiviral plastic surfaces (Yahya et al., 1986).

The concept of developing a hygienic surface susceptible to antiviral agents on recycled plastic, paves the way to a highly economic rate of return with versatile and wide applications. This application could find its way also in to electrical appliances (plastic coats on screens and keypads), hand sanitizer depots, plastic door handles, pens, bank cards, coffee shops' surface areas for customers, etc. Needless to say, the medical application field will be of much greater potential not only for economic benefits but also safety purposes compared to plastics used through conventional mechanical recycling. The environmental implications of this idea could be of significant potential in the current climate of research and development – with great emphasis new research trends are called to address the global spread of COVID-19. At present, the consensus and method for combating COVID-19 seems to be based on the rather simplistic approach of surface wiping and clean-ups. Surfaces are recommended to be wiped with organic agents that are well-known to kill the deposited viruses. In fact, using such organic-based antiviral agents, taking chloroquine as a typical example, has severe disadvantages and limitations. These could be summarized as their short-lived nature which requires constant re-wiping and re-applying to the

surfaces, and these agents possess noxious ingredients with harmful environmental implications. Therefore, it is necessary to employ different types of such agents that are environmentally friendly and work synergistically with the substrates without causing degradations. They must possess a high degree of biocompatibility and great effect as viral protective coating. They can be used efficiently for frequently touched surfaces made from different materials, in particular plastic waste.

Therefore, employing plastic waste surfaces can also present the advantage of having copper, and copper alloys and their nanocomposite *nanopowders* to be used as a permanent surface protective, coating the recycled plastic surfaces against COVID-19. The use of such “nan-coats” can easily be applied on such surfaces which also presents a new venture for this idea of using PSW as a means to develop antiviral surfaces. Copper and its alloys and nanocomposites can be safely used to coat all types of solid materials without exceptions. The United States Environmental Protection Agency has registered 355 copper alloys with public health claims (Davis, 2004). The products made from any of these registered alloys are legally permitted to make public health claims relating to the control of organisms that pose a threat to human health. In order to ensure a successful coating process and to produce homogeneous porosity-free plastic-coated systems by copper or copper alloys, cold spray coating technology is proposed (El-Eskandarany and Al-Azmi, 2017). In contrast to the conventional thermal spray approach, cold spray is a solid-state process, in which the copper nanopowders’ feedstock remain in their solid form without melting and/or grain growth. The production of such surfaces could pave the way for a having an antiviral product that would ideally encompass over 90% by weight of PSW in it (Al-Salem et al., 2015). Such a high content of PSW would be sufficient from plastic film waste (Al-Salem, 2019). This also presents new opportunities for having substrates from biodegradable (hydro-based) plastic blends that could be used as a *greener* alternative as well. It should also be stated that there is a clear economic impact for proposing such a product at these difficult times where COVID-19 has resulted in many job losses and economic burdens (Hu, 2020; Mann et al., 2020). The master-alloy (e.g. silver-based or copper-based) could be valorized from industrial waste sources. The production of such a SW based product will cost minimal production amounts, and will result in: (a) diversifying the research trends of the future, merging engineering and bio-technology sciences; (ib) create economic opportunities that could lead to new job opportunities in the field of antiviral and protection equipment for medical sectors; and (c) decrease infection and transfer of COVID-19 in vital sectors such as the healthcare system.

Furthermore, the research concept presented here could also provide a paramount solution for the healthcare sector the world over. Preventing COVID-19 from transferring through various routes within medical facilities is vital to minimize risk to patients. There still exist various medical equipment and applications that could be replaced with such a concept, namely in

surgical theatres or the medical supply chain in general (Gereff, 2020; Mori et al., 2020). Such a concept could also be used for flooring and roofing in healthcare facilities to reduce contamination or transportation of the virus among vulnerable patients. Moreover, it could also be implemented for masks and face shields as part of personal protective equipment that requires a dedicated separation, sorting and recycling line within an integrated SW management scheme due to the nature of its materials. The production of such a material could also be integrated within a holistic SW management system. Either material recovery facilities or mechanical sorting lines could segregate the polyolefin-based waste for further processing and compounding. This will not have an additional toll on the design of existing infrastructure as it stands. It will also reduce environmental indicators due to the green and environmentally friendly nature of the product that utilizes a SW feedstock.

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ORCID iD

Sultan Majed Al-Salem  <https://orcid.org/0000-0003-0652-4502>

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