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Poderia a crise pandêmica por COVID-19 estimular práticas de economia circular? Uma breve reflexão

Could the COVID-19 pandemic crisis stimulate circular economy practices? A brief reflection

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ABSTRACT
The practice of more sustainable actions is essential for maintaining environmental quality in the long term. It is not by chance that governments, the private sector, and the organized civil society discuss aspects associated to the circular economy, which has as one of its pillars the 'closed' integration between natural resources and industrial waste in the productive cycle. Circular economy remains far from being a global reality, whether due to the existence of political barriers, or to the lack of interest on the part of private organizations in investing in new manufacturing models. However, crisis scenarios can accelerate innovations in the sector. The worldwide pandemic that started in January, 2020 due to the spread of a coronavirus can be one of those driving forces. Since the fast and worldwide transmissibility of this new type of virus was detected, stocks of PPEs have become scarce, triggering a race to produce hospital masks. Initiatives aimed at proposing alternative methods of manufacturing IPEs have also multiplied to meet the immediate demands of healthcare professionals. Only in the first quarter of the current year, numerous projects for manufacturing face shields and masks have emerged. The present work aims to evaluate, in a preliminary way and in a short period of time, whether the dynamics triggered by the worldwide pandemic of the severe acute respiratory syndrome can accelerate circular

economy practices that, in a normal situation, could perhaps not exist or take years to happen.

Keywords: Circular economy; pandemic; polymers; do-it-yourself

RESUMO
A prática de ações mais sustentáveis é essencial para manter a qualidade ambiental a longo prazo. Não é por acaso que governos, setor privado e sociedade civil organizada discutem aspectos associados à economia circular, que tem como um de seus pilares a integração 'fechada' entre recursos naturais e resíduos industriais no ciclo produtivo. A economia circular permanece longe de ser uma realidade global, seja devido à existência de barreiras políticas ou à falta de interesse das organizações privadas em investir em novos modelos de fabricação. No entanto, cenários de crise podem acelerar inovações no setor. A pandemia mundial que começou em janeiro de 2020 devido à propagação de um coronavírus pode ser uma dessas forças motrizes. Desde que a rápida e mundial transmissibilidade desse novo tipo de vírus foi detectada, os estoques de EPIs se tornaram escassos, desencadeando uma corrida para produzir máscaras hospitalares. As iniciativas destinadas a propor métodos alternativos de fabricação de EPIs também se multiplicaram para atender às demandas imediatas dos profissionais de saúde. Somente no primeiro trimestre do ano atual, surgiram vários projetos para a fabricação de escudos e máscaras. O presente trabalho tem como objetivo avaliar, de maneira preliminar e em curto período de tempo, se a dinâmica desencadeada pela pandemia mundial da síndrome respiratória aguda grave pode acelerar práticas de economia circular que, em uma situação normal, talvez não existissem ou não levar anos para acontecer.

Palavras-chave: Economia circular; pandemia; polímeros; Faça Você Mesmo

1 INTRODUCTION

For many years society has discussed the importance of maintaining a more sustainable lifestyle, in which natural resources can be used more consciously. A more currently used concept – the circular economy (CE) – proposes a series of measures to be adopted by different actors (governments, companies, the civil society, etc.) (Babbitt *et al*, 2018; Tukker, 2015) aiming at reducing waste, whether urban or agro-industrial. Around the world, government agendas have provided opportunities for discussing sustainable practices. However, many believe that this reality still falls short of what would be needed to ensure better environmental quality. That is because to reverse the current scenario of environmental degradation requires a synchronization of various productive sectors in an overly complex logistics chain both at national and international level. Some factors, however, can stimulate the development and adoption of technologies and/or productive processes based on a circular economy, such as: the need to reduce costs in transportation, which can facilitate the transfer of new technologies between companies (Coe *et al*, 2004);

stricter environmental legislations (Wang and Liu, 2007); and environmental problems (Su *et al*, 2013). One of the factors that until then could be seen as unlikely to accelerate circular economy is public health. Currently, with the global crisis generated by the Covid-19 pandemic, governments have faced challenges not just in health and hospital management. In the absence of many inputs needed to ensure protection for medical and nursing teams, hospitals are mobilizing to resort to low-cost and easily accessible alternatives without, however, reducing the safety of health professionals.

2 METHODOLOGY

As the present work consists of a survey based on recent events and with no scientific publication correlating pandemics with circular economy practices, this research was based on data obtained from different press media. From them, it was possible to observe that initiatives aimed at the manufacture of alternative PPEs, as a way to meet the demand of healthcare professionals. However, only examples being used by hospitals were considered.

3 CIRCULAR ECONOMY (CE)

The concept ‘circular economy’ (CE) has frequently been adopted and promoted by the European Union, governments, and many world organizations (Park and Chertow, 2014; Tseng *et al*, 2020). It has been recommended as an approach to promote economic growth in line with environmental sustainability (Korhonen et al, 2018). Its concept is based on the counterpoint to the current production system, in which the flow of production and energy is linear. In the EC, the idea is to propose changes in the production chain in such a way that there is a reduction in the environmental impact, stimulating new business opportunities (Desrochers, 2002; Babbitt *et al*, 2018; Manninen *et al*, 2018; Lewandoski, 2016; European Commission, 2015; Ghisellini *et al*, 2016), industrial integration (Su *et al*, 2013), and benefits to society (Ghisellini *et al*, 2016). Unlike the usual recycling techniques, the EC policies focus on reusing products, components, and materials; remanufacturing, refurbishing; repairing; as well as reusing energy (Tseng *et al*, 2020; Geissdoerfer *et al*, 2017; Rachid *et al*, 2013; Braungart *et al*, 2007). In this sense, business practices based on this concept demand less natural and energy resources (Korhonen *et al*, 2018).

The pandemic situation the world finds is currently facing has mobilized people, companies, and governments to a degree very close to that seen in the Second World War. Perhaps at that time in Human History, though briefly, the practice of circular economy was already employed. In the absence of conventional inputs, in order to manufacture parachutes, the US government resorted to cheaper and easily accessible options. Pantyhoses were used, all made of polyamide, which was the base of the fibers used in the parachutists' equipment (Wakenfield, 2007).

Foreseeing a pandemic situation, the Institute of Medicine (2006), through its Committee on the Development of Reusable Facemasks for Use during an Influenza Pandemic produced a report in which it evaluated the reuse of respirators and medical masks as a means of preventing or reducing transmission of the influenza virus in situations where the supply was deficient. Recalling past epidemics, such as the Spanish flu (1918-1919), which caused more than 500 thousand deaths; the Asia flu (1957-1958) and; the Hong Kong flu (1968-1969), they highlighted that in a pandemic crisis, time and planning are crucial to guarantee those IPEs are available on the market. They reported that in the absence of supplies, N95 masks could be used beyond their limit, in order to guarantee some level of protection. The same Committee pointed out that do-it-yourself masks could be made for individual use. It is worth noting that this Committee was established in 2006, assuming a pandemic scenario, in which supplies could run out in the short term.

3.1 INITIAL PRACTICES OF CIRCULAR ECONOMY STIMULATED BY COVID-19

If, on the one hand, the scientific community has been working hard to develop vaccines and drugs capable of fighting the virus, on another front of this battle against the invisible enemy there are obstinate volunteers. Designers, engineers, students, and self-employed professionals around the world strive to propose alternatives for PPEs (individual protection equipment) for hospital use. This is because supplies have run out quickly due to global demand, especially for masks to protect against certain aerodispersoids. China, for example, since March 2020, started to produce 200 million units of masks/day (more than 20 times the amount manufactured in February of the same year), with 600,000 units referring to the N95 mask. Even so, the quantity is below the amount needed to meet local and international demands (Feng, 2020). In Brazil, another country plagued by the pandemic, the federal government acquired the entire production capacity of the 3M Brazil. With this, it is estimated that the local demand will be provided with 1.8 million units of masks (Portal G1, 2020). In the last few months – in record time - there have been many examples of developing alternative PPEs in the 'do-it-yourself' style (Lee, 2020).

One of the PPEs most aimed at being manufactured in this pandemic period is the N95 mask. This type of mask is intended to cover the mouth and nose, providing adequate sealing when in contact with the user's face. A practical way of assessing whether the sealing is effective can be learned through the guidelines of the Occupational Safety and Health Administration (OSHA, 2020). In the video tutorial, sealing is guaranteed if, when using the mask, the user does not perceive the odor of one of the following chemicals: isoamyl acetate (characteristic of bananas), saccharin, bitrex, and smoke. Produced from interwoven polypropylene fibers (Institute of Medicine, 2006), the N95 acts as a pathogen barrier in the form of aerosols with dimensions below 5µm and that remain suspended in the air for long periods of time and can penetrate the respiratory tract more deeply if inhaled (Anvisa, 2020; WHO, 2020). When necessary for use in a hospital environment, this mask must have minimal approval. In other words, it must have been certified according to the NIOSH 42 CFR 84 regulations (Balazy et al, 2006). In this case, the mask is classified as N95, with a 95% filtration efficiency for NaCl aerosol. It is similar to the PFF2 adopted in Brazil and indicated for environments contaminated by coronavirus (Anvisa, 2020; Colton, 2004).

The N95 is known to be used in contaminated environments, acting as a barrier against some pathogens. With the depletion of the global stock, some health professionals have been working with conventional surgical masks. It is evident that the risk of contamination by coronavirus is imminent. But, in studies related to the efficiency of those masks as barrier to the influenza virus, Loeb and co-authors (2009) observed that they were similar in efficiency to the N95 masks. They highlighted that, in environments where contamination by pathogens in the form of aerosols (bronchoscopy and intubation procedures) is a high risk, the use of N95 is prudent. However, in their studies, they considered feasible the use of surgical masks as PPE against contamination by *influenza*.

Next, initiatives will be presented as complementary to the provision of PPE for healthcare professionals which, even without certifications, are based on technical information for making similar products.

3.2 HOW TO MAKE FACE SHIELDS

Another PPE used in environments contaminated by microorganisms is the face shield, a mask designed to cover the entire face and consisting basically of a transparent polymeric material visor (Norman, 1995).

The Massachusetts Institute of Technology (MIT) began to massively manufacture face-shield-like masks for healthcare professionals in April 2020. It was designed to be easily assembled and with a low production cost, since they must be disposable. In addition, they must be made with inputs available on the market, which is a challenge in times of crisis, according to observations made by Mechanical Engineer Martin Culpepper, the project leader.

The parts are made of polycarbonate sheets, cut on machines capable of producing thousands of sheets per hour. The laminates are initially manufactured by Polymershapes, based in Boston, and sent to hospitals, where healthcare professionals can assemble them very quickly. The company intends to extend production to 55 locations in the USA, possibly reaching a production of millions of units per day (Hitti, 2020).

3.3 DELVE'S INITIATIVE

DELVE – the consulting company – has also engaged in the voluntary campaign to disseminate techniques for making face shields. To this end, it made available a document containing specifications for manufacturing them, with a list of inputs and mask dimensions. For the shield, transparent polyester is recommended; and polyethylene terephthalate (PET), PET-G, or polycarbonate (PC) can also be used. Figure 1 shows the structure of the mounted mask, as well as the dimensions of the transparent shield.

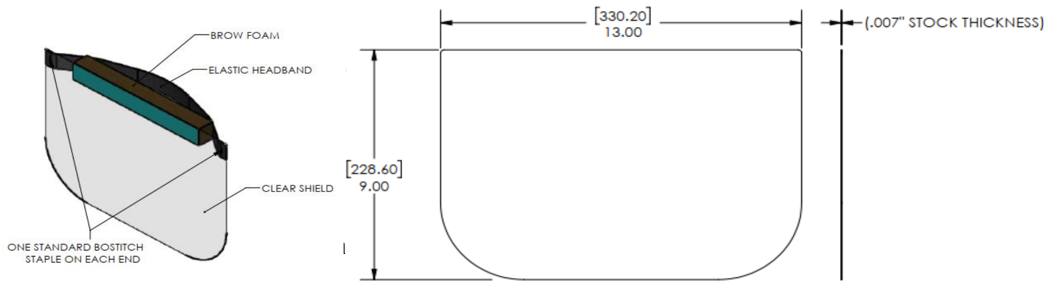

Figure 1. Dimensions of the transparent shield (DELVE, 2020).

According to the representatives of the initiative, the average production cost per unit is US$1.5. This figure considers only expenses with materials. Despite the publicizing project, the representatives stressed the importance of maintaining good production practices, although there is no need to sterilize the masks.

Aiming to expand the PPE access to healthcare professionals in India, Khurana and co-authors (2020) proposed alternatives for making face shields. The masks were produced with polymeric materials available on the market, such as polyurethane foam (PU), transparent sheets, and elastic strips. The average production time is 2 minutes. The estimated unit cost was 15 Indian rupees. According to reports from resident physicians, the masks can be used for 4 hours without discomfort.

3.4 N95 MASKS

The present work does not intend to indiscriminately encourage the use of alternative materials for producing PPE by healthcare professional, but to point out that human ingenuity may contribute to save lives. Commercial quality masks are not always accessible for several reasons. During the Manchurian plague, however, handmade cotton masks were used for the primary protection of healthcare and military professionals (Capps, 1918; Kool, 2005). Thus, in situations where commercial PPEs are not available, ‘homemade’ masks could be used (Dato *et al*, 2006). However, the authors consider that, although those masks offer the possibility of protection in relation to aerosols, difficulties are encountered due to: the material used, to the type of assembly, to the facial structure, to cultural practices, and to handling. Despite these challenges, the authors reinforce the need for innovations in the respiratory protection sector, in which materials can be replaced by those conventionally used. The US Department of Health and Human Services (DHHS), when evaluating a possible pandemic scenario (due to influenza), in which supplies for manufacturing respirators and medical masks could be exhausted in the short term, established a Committee to evaluate the possibility of reusing N95 masks or even manufacturing them for individual use (Institute of Medicine, 2006). The same Committee was asked about the possibility of using alternative materials with a level of protection similar to that of the traditional ones.

Li and Gong (2015) investigated the use of nanofibers for making particle barrier masks with an average diameter up to 2.5 μm. The nanofibers were obtained by electronspinning from a solution of polysulfone (18%w/w) in a mixture of acetone/dimethyl acetamide. All of them showed a white color and were homogeneously distributed in non-woven fabric, as shown in Figure 2.

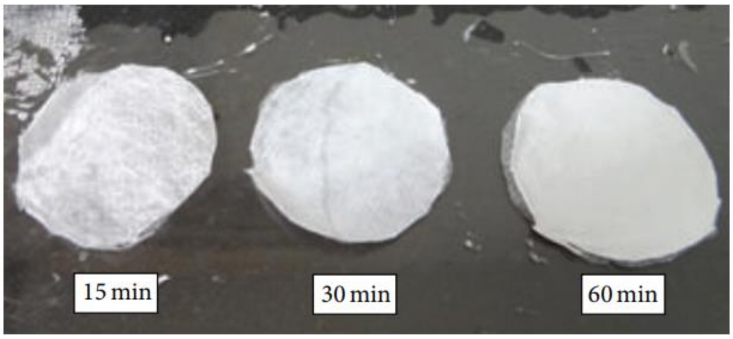

Figure 2. Masks made of nanofibers on non-woven fabric (Li and Gong, 2015).

In a scanning electron microscopy (SEM) analysis, it was observed that the nanofibers obtained during 15 minutes of electrospinning had an average diameter between 500 and 800 μm, with random orientation and high porosity, as shown in Figure 3.

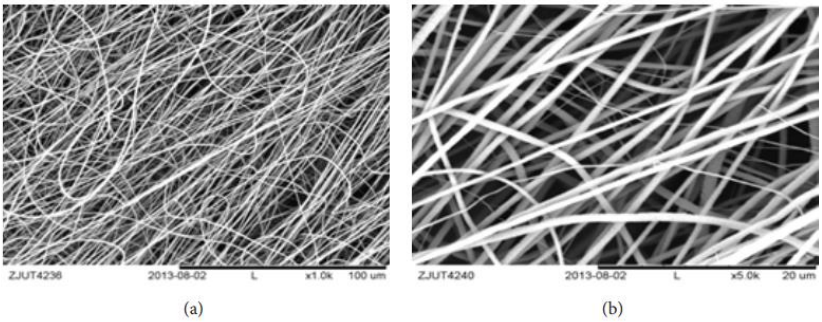

Figure 3. SEM photomicrographs for polysulfone-based nanofibers produced by electrospinning: (a) 1000x magnification; (b) 5000x magnification (Li and Gong, 2015).

In their research, the authors concluded that masks made of those nanofibers were effective in retaining PM2.5-type particles, preserving their breathing capacity.

Some US hospitals and medical centers have adopted do-it-yourself practices to circumvent the shortage of PPEs. Others have improvised PPEs, assigning devices designed to be used by construction workers to their health professionals. Some physicians have adopted the domestic washing of N95 masks with bleach for later reuse. The Providence hospital network (in the state of Washington, USA) has loosened the guidelines of federal authorities, allowing health professionals to use the masks for longer than specified (Elgin, 2020); all following recommendations from the US Centers for Disease Control and Prevention. Making homemade N95 masks requires the aforementioned precautions regarding material selection. The anestheologist at Wake Forest Baptist Health, Dr. Scott Segal, provides a criterion for choosing material: passage of light. The more difficult the light is to pass through the material, the more suitable it will be for making the mask. On the other hand, the easier it is for light to pass through – and it is possible to see the fibers in the fabric – its use should be rejected. The choice, however, must guarantee the retention of viral particles and the user's breathing through PPE. At the Missouri University of Science and Technology, environmental engineer professor Yang Wang studies a combination of different materials, such as air filters and fabrics. His research group tested two types of filters. An allergy-reduction HVAC filter worked the best, capturing 89 percent of particles with one layer and 94 percent with two layers and an oven filter. The latter – in order to guarantee 95% efficiency similar to the N95 – had to be made with 6 layers. Still according to professor Yang Wang, the drawback of air filters is that they are composed of small fibers. So, if you choose to use air filters, they must be constructed with a double layer of cotton fabric. This prevents inhalation of small fibers present in the filters. In their investigations, the research group found that a 600-thread-count pillow case fabric offered a 22% article retention when folded. But when using 4 layers, this retention increased to 60%. A thick woolen yarn scarf, on the other hand, offered a 21% barrier with two layers. This percentage surpassed 48% when using 4 layers. A mask made entirely of cotton fabric used in bandanas had the worst result. Retention was only 18.2% when using two layers. The use of 4 layers promoted only a 19.2% retention (Pope, 2020).

4 CONCLUSION

Although the use of certified and appropriate PPEmust be emphasized in a highly contagious environment, emergency situations require simple measures capable of reconciling safety to healthcare professionals with the capacity to be produced using unconventional materials. The use of alternative materials can be useful in facing global crises, in which stocks of hospital supplies are scarce. In this case, aiming to minimize harmful effects arising from the lack of supplies in some places or countries where the health system is precarious, actions such as those currently observed around the world should be encouraged, safeguarding lives and being a message of hope in the fight against other pandemics. The examples cited throughout the present work illustrate action, though embryonic, of circular economy. If refined and improved, they can, in the future, be applied to the medical input production chain, representing new business opportunities.

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