Enhancing Personal Protective Equipment

Anti-viral functionality: Soap-like polyurethane coatings to enhance and extend the usable life of Personal Protective Equipment (PPE)

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A second research programme has commenced in the Polymer IRC Laboratories at the University of Bradford, in a joint project between Chemistry & Biological Science and the Polymer IRC. It is exploring the potential for a strong polymeric coating material for PPE and medical instruments which has antiviral behaviour. This is based on research in Prof Rimmer's group, to synthesise modified polymers and the Polymer IRC expertise to process and characterise these for usable products.

The project is warmly supported by the Deans of FoLS and FoEI, and funded through the Polymer IRC. It is led by Prof Phil Coates and Prof Steve Rimmer, and began on Thursday 21 May, with Nehnah Siddique (Chemistry), Prof Adrian Kelly and Glen Thompson (Polymer IRC) undertaking experimental work in the IRC Laboratories to asses the novel polymer, and make coated samples on typical substrates for PPE items. Liverpool School of Tropical Medicine and Lancaster University have agreed to undertake anti-viral testing of our samples.

Fuller details of the project are shown below:

The problem PPE- predominantly gowns, gloves, face masks and face shields – is not only in short supply in the current crisis, but there also tends to be significant constraints on the time an item can be used for, and potential spread of infection by handling of PPE after use/ danger in attempting re-use. PPE is not only required for current front-line medical staff but is likely to be required for many of us as lockdown is eased, perhaps over a long period.

A potential help – novel anti-viral polymers There is therefore a potential advantage in extending the lifetime of PPE, and its effectiveness. We propose investigating adding anti-viral functionality, using cost-effective and scalable polymer coatings and additives. Bradford is uniquely placed to attempt this by bringing together our chemists and engineers in an effective partnership, aiming to mount a successful *substantial bid to UKRI*.

The Key Concept Soap is arguably the most effective killer of corona viruses. Soaps are charged amphiphilic compounds that for centuries have been used to kill microbes. Generally, the charge is due to either sulphates or phosphates. These act by breaking up the membranes of bacteria. Coronaviruses are much simpler organisms than bacteria: soaps act to disrupt the protein envelope that surrounds the virus RNA. However, soaps cannot be used to coat devices practically, and if they are blended into PPE they will be rapidly washed away. Polymeric analogues of soaps can be prepared and nature uses this concept as its main defence against bacteria by providing anti-microbial peptides (AMPs). Synthetic polymers are superior to AMPs as coatings, and in particular polyurethane (PU) coatings are tough and flexible and used as high performance coatings in both domestic and industrial settings. Quarterniary ammonium salts are related to soaps and the feature heavily in the current list for the EPA (USA) as disinfectants for SARS(ref). In a UKRI bid we will hsve the option to produce also PU coating with quarterniary ammonium funtionality. All disinfectants are associated with environmental hazards and as low molar mass compunds they can easily enter water courses etc. In our view polymeric coatings are much more evironmentally acceptable and enter the envoronment much more slowly.

Our capabilities PhD work in the Polymer and Biomaterials Chemistry Laboratories (Nehnah Siddique, a self-funded student in the School of Chemistry and Biosciences) involves synthesis of a potential anti-viral thermoplastic PU. This is a soap-like phosphate functional polymer. (The current project focuses on environmental degradation for enhanced compost (containing phosphate) after use as part of a cyclic process.) Around 50g of our polymer is currently synthesised and ready to be used in exploration of coating of metals, rubbers and plastics, and processability (thermal analysis, compression moulding) to make testable small samples. In due course, when larger amounts can be synthesised or the formulation varied (with lab & chemicals access and suitable H&S) we can explore moulding, fibre extrusion/co-extrusion in the Polymer IRC. We propose that its soap like nature will protect PPE allowing for extended use, which will allow manufacturers to maintain supply more effectively. Importantly, the UK has expertise in coatings (eg Akzo Nobel) with PUs to allow us to rapidly scale up to manufacturing.

What is being done

1. We are evaluating processability (thermal and rheological properties, moulding) and detemining the physicochemical and mechanical properties of samples. Early results are encouraging, indicating a processable and stable material.
2. We are producing coatings on samples of materials used to make gloves, gowns and face masks, using a solvent coating process and where possible melt coating processes. In these early experiments we use a "draw-down solvent-based" process, as used in the industrial formulation of paints, early in the formuaion process. In a large scale manufacturing process spraying, dipping or roller coating woud be used. Melt coating will initially use compression moulding. Early results are encouraging with good samples made by both solvent coating and by compression moulding, on PET-g sheet (the material used for visor faceplates).
3. We have produced a range of samples to mount in '24 well plates' and shipped these to the Liverpool School of Tropical Medicine, LSTM [Dr Grant Hughes and Dr Ian Patterson], and Lancaster University [Dr Muhammad Munir] who will then test the ability of the coated materials to resist contamination with coronaviruses in their Containment Level 3 facilites.

If sucessful our colleagues at LSTM and Lancaster will form key partners for a UKRI bid. If showing promise, we need to synthesise more materials (and potential variants of these polymers) and examine the capability for other processing technologies by blending; e.g. co-spinning, co-extrusion, injection moulding, blow forming.

REFERENCES

These provide some background, and also relate to potential opportunities in a larger project.

1. https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2
2. The need for PPE designs that will help avoid proliferation of the virus:

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3. Enhancing PPE, e.g. by extending safe use period, will improve both function and economics

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