Polymers Processing and Recycling Techniques
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Lecture – 74
PolCoPUS: Recycle, Up-down Cycling II

Hello, welcome to the course on polymers in which we are discussing concepts, applications, properties and sustainability. This is towards the end of 10th week where we are trying to analyze the polymer processing and recycling techniques. As we wind up our discussion of processing and recycling techniques, we have to look at what are the alternate possibilities of doing this upcycling as effectively as possible, also incorporating renewable sources in them and so keeping the overall sustainability in mind what are the strategies available?

So having done this discussion, then we will move on to looking at the flow behavior itself and understand the rheology of materials in much more detail so that all of these processing and recycling operations could be done effectively based on the knowledge of rheology.

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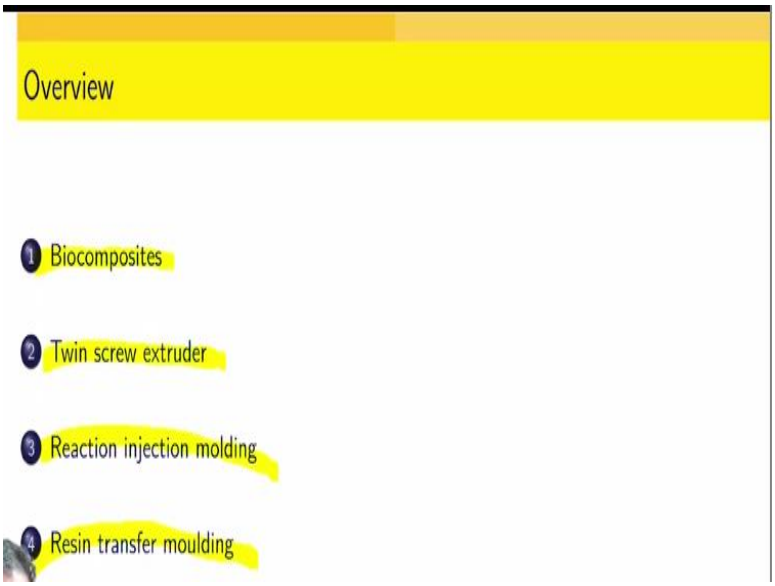

So, we will look at biocomposites as a possibility where some part of the recycled material incorporates renewable source-based polymers and then more importantly can we effectively exploit the techniques which are available for polymer processing in the context of biocomposites. So, can we use twin screw extruder which is an excellent device for mixing? Can we use the reaction injection moulding in which case we combine moulding and reaction operations and resin transfer moulding which can give us quite complex shape including the

reinforcement, can this be done effectively for biocomposites?

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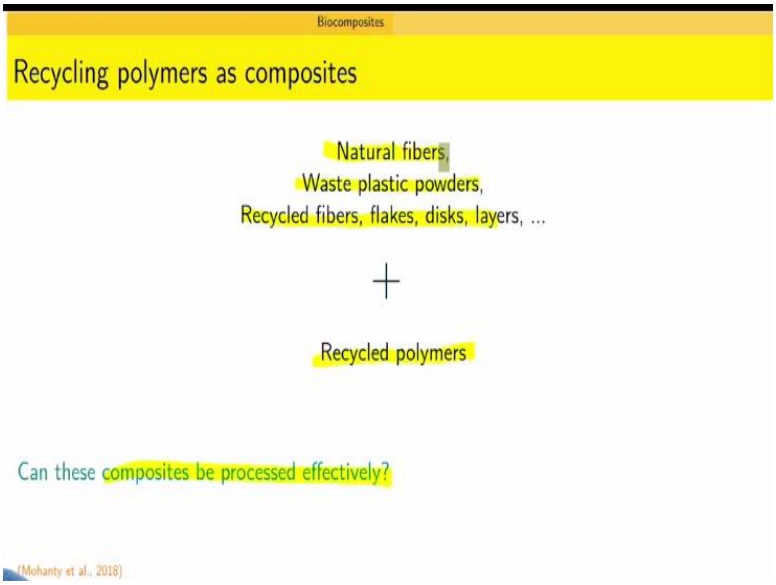

When we mean biocomposites what we are saying is can we not use natural polymers, some of the other fillers which are again arising from waste plastic as well as many other recycled materials along with the polymers and can we have effective composites based on these? Because if we are able to do this, what we are doing is effectively utilizing fibers, flakes, discs, layers, powders, different forms of waste plastic.

So we are not constraining itself in terms of a pellet of pure polymer which is available as a recycled plastic. Secondly, we are also using natural fibers which are based on renewable sources and incorporating it in this composite product.

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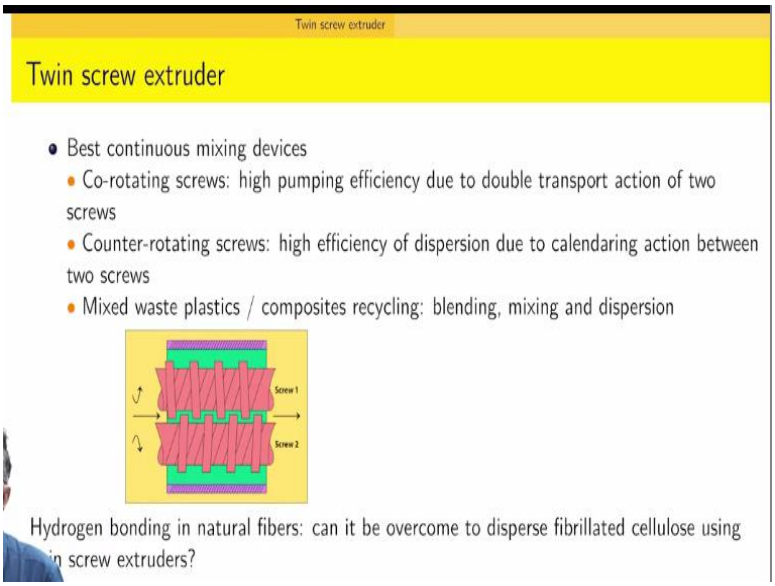

So we can look at use of twin screw extruder as a possibility in the recycling operations. We have this as the one of the best devices in terms of mixing. It comes in co-rotating as well as counter-rotating version, so you can have screws which are counter-rotating or both of them are rotating in the same direction and so this way you can achieve pumping efficiency in one case or very high efficiency of dispersion in other case.

And given that we are looking at mixed waste plastic composites recycling, blending, mixing and dispersion are key requirement. So therefore, the twin screw extruder can be used, but the question ah for example is that it can it disperse also cellulose? And the cellulose fibers are very strong because of the hydrogen bonding which is present in them, but if we disperse by breaking these hydrogen bonding, we will get fibrillated cellulose which can do a much better task of reinforcement, so is that possible? So that is something for us to think about.

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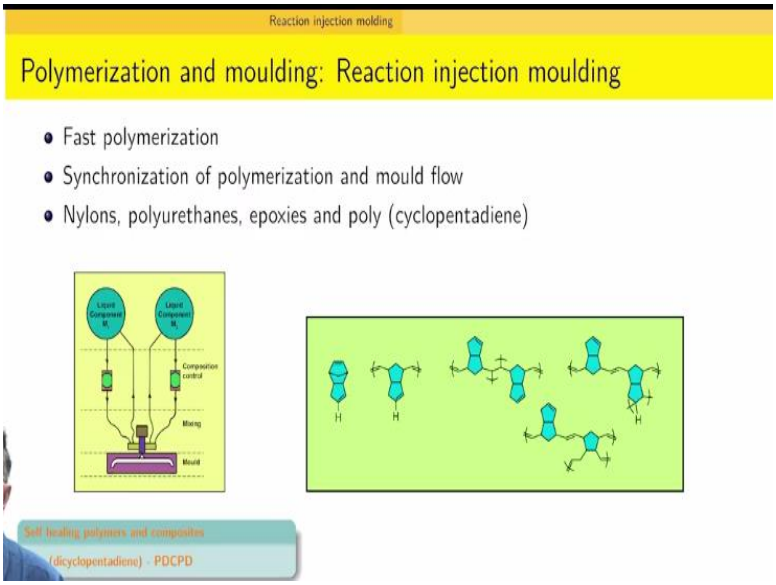

We can also think in terms of an alternate process of using reaction injection molding because whenever there is fast polymerization, we can do synchronization of polymerization and mould flow. So effectively we are combining the polymerization operation and moulding in one and this is quite commonly used for nylons and polyurethanes and epoxies and also one of the polymers which is cyclopentadiene can also be made using this.

Basically, the idea is to start with both components monomers or monomers and catalysts, monomers and initiators and then meter and mix them and then basically make them flow into the mould and as soon as mixing starts happening, reaction starts and in a quick amount of time it should be made to flow in the mould so that polymerization reactions can be

completed and solidifications can set in.

In case of cyclopentadiene, it is a promising polymer where it can be used also as a self-healing polymer. So many of the composites if you read about self-healing materials where let us say a crack develops what you can do is this cyclopentadiene can be kept as small capsules and then as soon as crack happens the cyclopentadiene capsule also breaks, but it then flows and then reacts instantaneously because of the fast polymerization process and therefore we can use it as a self-healing material.

It can be also moulded in this reaction injection molding to give you parts which are quite effective in their properties. Other enhancement that can be done keeping biocomposites in mind is can we not have a 3D fiber preform of natural fibers and can we not do what is called a structural reaction injection molding? So in which case, in the mould we already keep the fibers and then have the monomers and the overall components flow in and reaction at the same time.

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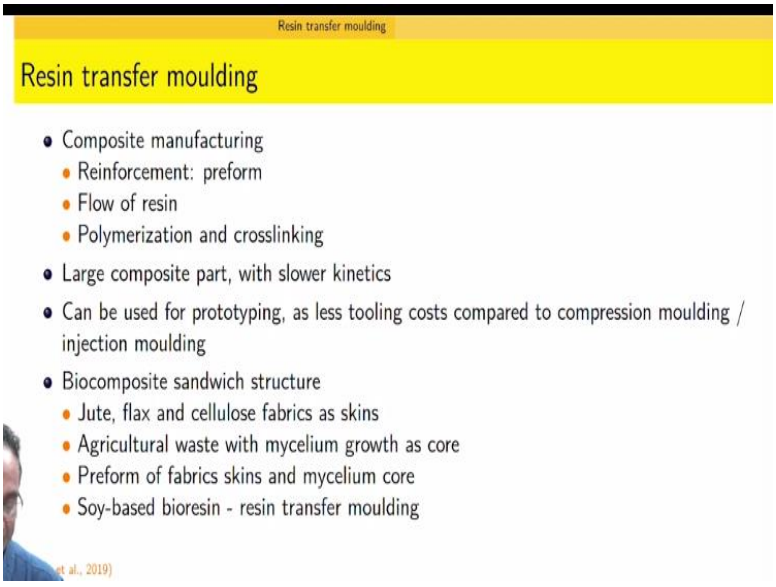

The resin transfer molding is also a similar technique where the fabric and fiber preforms are kept and then a resin is allowed to flow in and fill all the parts of the overall preform. This is used quite common in aerospace and defense applications and this is basically where composite manufacturing method where reinforcement is there, flow of resin is achieved and then polymerization and crosslinking happen, and generally this is used for materials which are slower crosslinking because extremely large parts are processed this way.

In reaction injection moulding, we are looking at small parts being moulded and also complex shape, while resin transfer moulding can be of not as complex shapes but very large parts, and so this is useful because the tooling cost associated with resin transfer molding is much less. Whenever you have injection moulding or any other moulding operation, you require a mould which is quite costly.

But resin transfer moulding uses bag and only the bottom surface is what is used for tooling. So therefore, it ends up being less costly compared to many other composites making or polymer making operations. So one question again that can be posed is can you make a biocomposite material and this is one example where jute and other fibers are used as skin material, agricultural waste is used as a core material.

And then a preform of the skin and the overall core is kept in a resin transfer moulding operation in which a bio-based resin or a polymeric material which is based on soy, which is a soy-based protein material which is in the resinous form can come in and then react and solidify and in the end we can get a biocomposite. So, almost this is like making wood itself. So can such a process be realized and will it be cost effective and influential?

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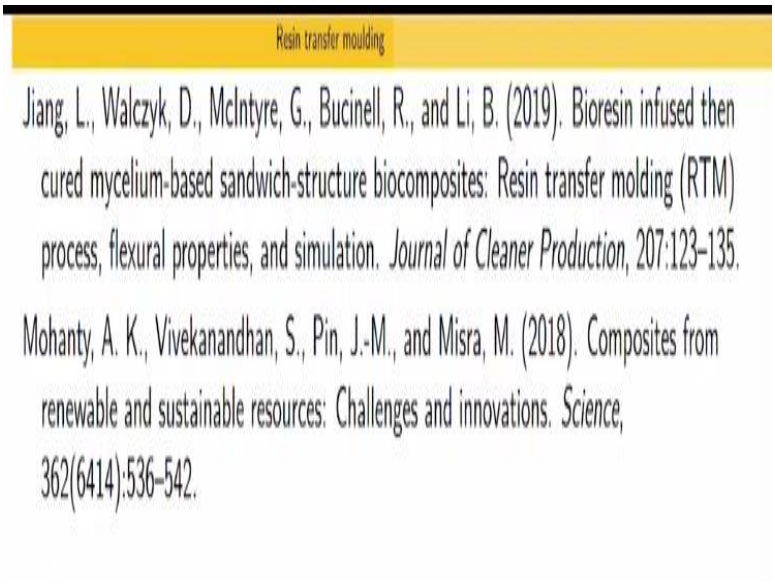

So with this, we will close this lecture associated with discussion of various ways of upcycling polymeric materials so that we have a wider variety of applications to choose from while recycling of these polymers are thought of. Thank you.