LARGE SCALE FABRICATION OF ENVIRONMENTALLY BENIGN NANOPARTICLES FROM LIGNIN FOR USE AS DELIVERY VEHICLES OF ACTIVE INGREDIENTS

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Our group previously introduced a new class of environmentally-benign nanoparticles (EbNPs) with cores made of biodegradable lignin (*Nature Nanotech.*, 10, 817, 2015). Unlike traditional inorganic nanoparticles, the environmentally benign nanoparticles made of lignin can degrade after they have been used, so there is no potential for toxic impact on the environment or humans. The lignin core nanoparticles are synthesized through flash precipitation, but until recently they were only produced in mL-scale batches. We have developed a semi-continuous system featuring a recycle loop, making it possible to produce such nanoparticles in practical quantities for industrial applications. We investigated the role of each variable in our process to determine how we can control the size of our EbNPs and the final concentration of the EbNP suspensions. Because of the turbulent flow in the system, we found that the range of possible flow rates did not have any impact on our final size. The amount of anti-solvent added to the medium also had no effect on our final EbNP size distribution, revealing that we have continuous nucleation throughout each run instead of the LaMer mechanism, which would result in growth of existing particles with the addition of more lignin. This allows effective control of the resulting nanoparticle size through the starting concentration of lignin in acetone. Then, by altering our anti-solvent volume, we can control the final NP concentration of our solution. Using our system, we are now able to make liters of more concentrated nanoparticle suspensions at a time. We will discuss a few applications of our EbNPs, including their role as highly efficient antimicrobials and antifungals. For making EbNPs that serve as antimicrobials, silver ions were infused into the lignin core and the nanoparticles were coated with a polyelectrolyte layer that enabled them to stick to bacteria. This formulation can dramatically decrease the use of silver in consumer products. We are also investigating the application of the EbNPs to other biological surfaces, such as leaves and hairs. We can coat the nanoparticles with a cationic biopolymer, chitosan, to make them adhere to these surfaces, and in some cases we have observed antifungal action even with unfunctionalized lignin nanoparticles alone.

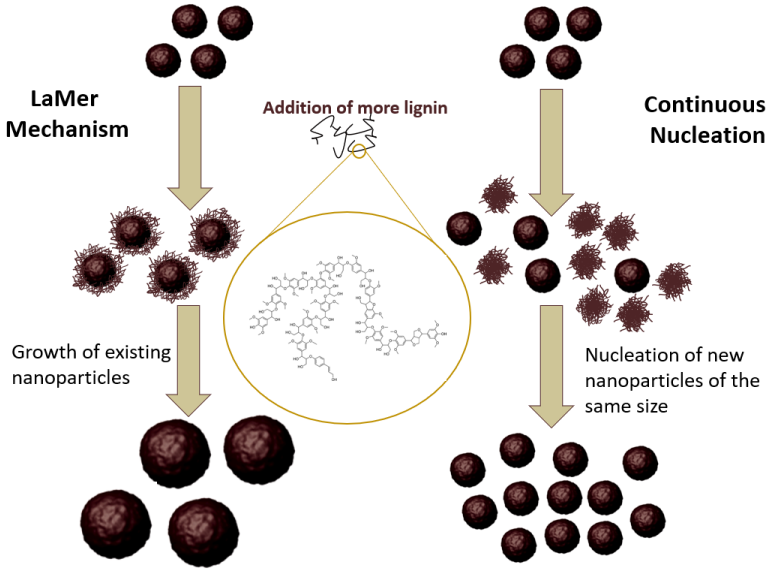

Figure 1- Possible mechanisms of organic nanoparticle formation resulting from addition of lignin to a solution of existing lignin nanoparticles.