Understanding PLA crystallization in complex processing operations: interrelation between plasticization, chain branching and foaming

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PLA is one of the few compostable materials that are readily available. Foams are often regarded as materials that are difficult to recycle. Because of this, the foaming of PLA has attracted immediate attention for replacement of PS foams. Research on this complex topic has generated very useful knowledge on the crystallization of PLA in processing conditions and under conditions of large plasticizer concentration. Crystallinity control in PLA foams is of primary practical importance to increase heat resistance to acceptable levels. Therefore, the PLA grade must be selected with a sufficient L-LA purity to enable crystallization. On the other hand, foaming crystallizable polymers is more challenging because they need to be processed at a higher temperature relative to their glass transition. A second issue with PLA foaming is the rheology. As a rigid polyester, PLA chains cannot entangle as readily as other commonly foamed material leading to a lack of elasticity or melt strength that is detrimental for foam stabilization. This paper will review and examine the interrelations between crystallinity development, chemical branching of PLA and rheology and will examine the consequence of these interrelations on the complex and challenging process of making low-density foams. It will be shown that high purity PLA can be melt processed very close to its crystallization conditions leading to a peculiar foam nucleation and stabilization mechanism. The presented phenomena encompass the technological aspects of foaming since they enable to understand the main challenges and characteristics of PLA processing.