

## 聚氯乙烯/杨木粉模压发泡材料的制备及性能研究

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**摘要:** **目的** 制备聚氯乙烯杨木粉发泡材料并研究其性能。 **方法** 采用模压法制备发泡材料, 利用压缩试验表征其性能。 **结果** 随着杨木粉填充量的增加, 聚氯乙烯杨木粉发泡材料的密度呈上升趋势。添加木粉后, 压缩强度呈先升高后下降的趋势, 当木粉填量为10份时, 压缩强度达到最大。随着木粉粒度的增加, 聚氯乙烯木粉发泡材料压缩强度也呈先上升后下降的趋势, 在木粉粒度为100目时压缩强度达到最大。 **结论** 可采用模压法制备聚氯乙烯杨木粉发泡材料, 发泡剂用量、木粉填量和粒度对发泡材料性能有一定影响。

**关键词:** 发泡木塑复合材料; 模压法; 压缩强度

中图分类号: TB484.3 文献标识码: A 文章编号: 1001-3563(2015)13-0005-03

## Preparation and Properties of PVC/Poplar Powder Composite Foam by Moulding Method

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**ABSTRACT:** The PVC/Poplar powder composite foam was prepared and its properties were investigated. The moulding method was used to prepare the composite foam, and the compressive test was used to characterize the properties of the composite foam. The density of the composite foam was increased as the filling content of poplar powder was increased. The compressive stress was increased firstly then decreased as the filling content of poplar powder was increased. When the content of poplar powder was 10 portions, the compressive stress was the maximum. The compressive stress was increased firstly then decreased as the mesh number of poplar powder was increased. When the mesh number was 100 meshes, the compressive stress was the maximum. The moulding method can be used to prepare the PVC/Poplar powder composite foam. The properties of composite foam were influenced by the content of AC foaming agent, the filling content and the mesh number of poplar powder.

**KEY WORDS:** wood/plastic composite foam; moulding method; compressive stress

木塑复合材料是近年国内外蓬勃兴起的新型复合材料, 具有木材和塑料的双重优良特性, 主要用于包装、景观、建材、物流等行业, 但与木材相比, 通常密度过大<sup>[1-3]</sup>, 应用领域受到一定限制, 因此发泡木塑复合材料成为木塑领域研究的热点之一。目前发泡生物物质纤维塑料复合材料绝大部分是聚氯乙烯基木塑复合材料<sup>[4-6]</sup>, 这主要是因为聚氯乙烯熔融指数高, 易

于发泡。就发泡工艺而言, 木塑发泡材料多采用挤出工艺<sup>[7-10]</sup>和注射工艺<sup>[11-14]</sup>, 模压发泡法尚不多见。利用废弃物杨木粉和热塑性塑料废弃物生产微发泡轻质发泡材料的研究相对较少。文中将初步研究发泡剂用量、木粉用量和木粉粒度对模压发泡材料的影响, 该研究成果可为PVC模压发泡材料的制备提供理论依据与参考。

收稿日期: 2015-02-09

基金项目: 国家自然科学基金(31300483); 江苏省苏北科技发展计划(BN2013003); 江苏省自然科学基金(BK20130971)

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## 1 实验

原料:杨木粉,自制,60~140目;聚氯乙烯树脂(P-440型),上海氯碱厂;偶氮二甲酰胺(AC发泡剂),上海文化化工颜料有限公司;钙锌复合稳定剂(603型),上海文化化工颜料有限公司;其他助剂,市售。

试样制备:将杨木粉干燥处理后与PVC及助剂按配方高速混合后放入金属模具内发泡,温度为180℃,时间为20 min。

配方:100份聚氯乙烯,0~25份杨木粉,0~12份偶氮二甲酰胺,5份钙锌复合稳定剂,以及其他加工助剂。

方法:参照GB/T 1939—2009《木材横纹抗压试验方法》进行。

主要仪器:自制高速混合机、平板硫化机、CMT5型电子万能力学试验机。

## 2 结果与分析

### 2.1 AC发泡剂用量对PVC发泡性能的影响

在不加杨木粉的配方下,首先通过控制AC发泡剂变量试验探索PVC发泡塑料的密度、压缩强度的变化情况。从图1可看出,随着体系中发泡剂用量的增加,试样的密度和压缩强度均呈下降的趋势。当发泡剂用量为8份时,PVC发泡材料密度下降最明显,较未添加发泡剂的PVC材料下降了0.373 g/cm<sup>3</sup>,在应变为0.4时压缩强度下降了20.21 MPa;当发泡剂用量为12份时,PVC发泡材料密度下降了0.439 g/cm<sup>3</sup>,压缩强度下降了23.16 MPa。这说明随着发泡剂用量的增多,单位体积材料所能承受的压力减小<sup>[15]</sup>,但添加12份AC发泡剂较添加8份时相比,下降并不明显。综合考虑发泡材料密度和压缩强度,选择添加8份AC发泡剂时较为合适。

### 2.2 杨木粉填充量对发泡材料性能的影响

由图2可以看出,在添加8份AC发泡剂的条件下,随着粒度为100目木粉填充量的增加,聚氯乙烯杨木粉发泡材料的密度呈上升趋势。这主要是因为单位体积内加入木粉提高了发泡材料的密度。添加木粉后,由于PVC树脂原有的均匀连续相受到木粉的影响,因此压缩强度均小于未添加木粉的树脂发泡后的压缩强度。加入木粉后,应变为0.4时的压缩强度呈先升高后下降的趋势,当木粉添加量为5份和10份时,

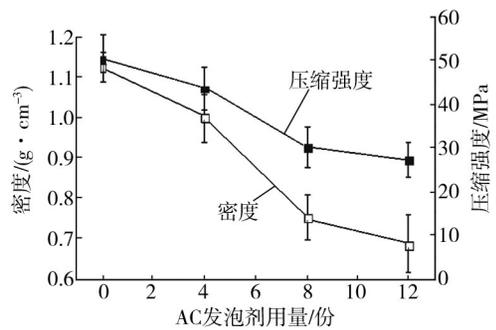


图1 发泡剂用量对密度和应变为0.4时压缩强度的影响

Fig.1 Effect of foaming agent on density and compressive stress at 0.4 strain

压缩强度分别下降了5.00 MPa和3.65 MPa。这说明木粉用量较少时,在发泡过程中一定程度上可以充当成核剂,促进发泡的进行,同时发泡对尖端裂纹有一定的阻止作用,木粉能被PVC基体充分包覆,使其在基体中能够均匀分布,因此有助于提高发泡强度<sup>[16]</sup>。随着木粉用量的不断增加,压缩强度又呈下降趋势。这主要是因为PVC含量不变的情况下,随着木粉的增加,原有树脂量不足以充分包裹木粉,使得发泡逐渐变得越来越困难,而且木粉的主要化学成分为纤维素、半纤维素和木素,其表面裸露着大量的亲水性—OH基团,PVC树脂与其相容性较差。当木粉用量较大时,木粉纤维中较多的分子内氢键易使木粉团聚现象加剧。当气体遇到团聚的木纤维时,渗透的气体迅速集中而形成巨大的孔洞,使其不能在PVC基体中均匀分散,导致发泡材料出现缺陷的几率增大,因此导致压缩强度的降低。

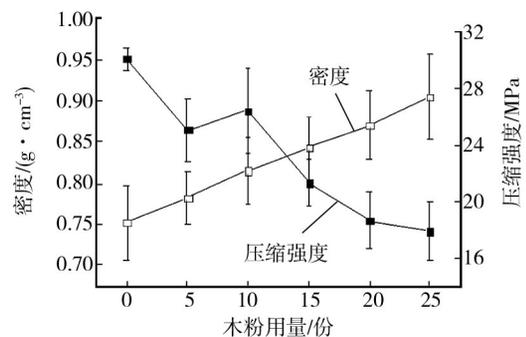


图2 木粉用量对密度和应变为0.4时压缩强度的影响

Fig.2 Effect of wood powder filling quantity on density and compressive stress at 0.4 strain

### 2.3 木粉粒度对发泡材料的影响

从图3可以看出,在AC发泡剂添加量为8份,木粉添加量为10份时,随着木粉粒度的增加,在应变为

0.4时压缩强度呈先上升后下降的趋势,在木粉粒度为100目时出现最大值26.47 MPa。这主要是因为当木粉粒度较小时,木粉纤维尺寸较大,在基料高混过程中,纤维与纤维之间易出现搭桥孔洞现象,易导致发泡的不均匀。此外,发泡剂分解时释放的大量气体,在自身的压力下易沿着这些大粒径的木纤维逃逸掉,而溶解到PVC树脂基体的相对较少,诸上原因引起发泡材料压缩强度降低。随着木粉粒度的增加,木粉纤维的粒径变小,木粉表面积增大,在树脂用量保持不变的情况下,树脂不足以完全包裹木粉。同时木粉的长径比一般随着木粉粒径的减少而减小,短而粗的木粉更易出现团聚现象<sup>[6]</sup>。此外长径比过小的木粉尺寸,使纤维素和半纤维素的羟基更易暴露,也易加剧木粉团聚现象,因此不利于发泡材料力学强度的提高。基于上述2种原因,当木粉粒度太大或者太小时,压缩强度相对较低,只有当木粉粒度合适时,才具有较高的压缩强度。

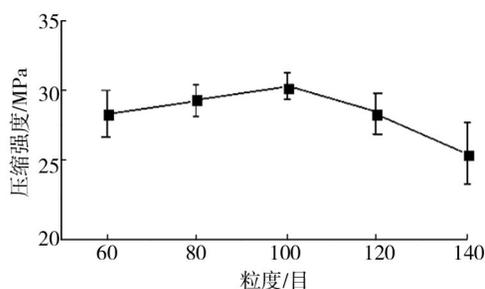


图3 木粉粒度对应变为0.4时压缩强度的影响

Fig.3 Effect of mesh number of wood powder on compressive stress at 0.4 strain

### 3 结语

1) 随着AC发泡剂用量的增加,试样的密度和压缩强度均具有下降的趋势。当发泡剂用量为8份时,PVC发泡材料密度下降程度最为明显。

2) 随着杨木粉填充量的增加,聚氯乙烯杨木粉发泡材料的密度呈上升趋势。添加木粉后,压缩强度呈先升高后下降的趋势,当木粉填充量为10份时,压缩强度达到最大值。

3) 随着木粉粒度的增加,聚氯乙烯木粉发泡材料压缩强度呈先上升后下降的趋势,在木粉粒度为100目时压缩强度达到最大值。

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