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Abstract

Bio-derived, fully biodegradable closed-cell micro- and nanocellular foams from gliadin, an abundantly available wheat storage protein, extracted with aqueous ethanol from wheat gluten, were produced in a newly derived foaming procedure using nitrogen (N_2) or carbon dioxide (CO_2) as blowing agent. The unique properties of this prolamin class were tested for qualification to sustainably produce versatile biopolymer foam by smart utilization of its abundant natural potential. For this process, dry gliadin powder or gliadin film was plasticized, in the simplest case using water, resulting in a viscoelastic paste that was then subjected to an atmosphere of nitrogen or carbon dioxide in a high-pressure cell. Subsequent tempering, followed by a sudden release of pressure and cooling resulted in closed-cell micro- or nanocellular foams. Depending on the type of blowing agent and the processing parameters, the foam morphology was tunable. Thus, cell size and density can be varied and become adjustable. Special emphasis was set on the role of the foaming temperature, pressure, pressure drop rate, type of plasticizer and its concentration, pH value, and pre- as well as past-expansion treatment. The resulting foams were thoroughly analyzed by scanning electron microscopy. Using supercritical carbon dioxide ($scCO_2$) instead of supercritical nitrogen (scN_2), a significant reduction of cell diameter with simultaneous increase of cell number density was obtained. If equal volumes of water and ethanol were used for gliadin plasticization, the cell sizes could be further reduced. All foams prepared via the proposed procedure exhibit the smallest cell sizes and highest porosity ever reported for foaming of wheat proteins. The procedure using abundant plant protein is clean, environmental friendly, simple and low cost, possibly leading to a technical realization and constituting a promising new approach for utilization of unique natural potential, e.g. for short purpose packaging, insulation, and application materials that are easily and environmentally friendly recyclable, and even edible.