Innovative civil engineering applications of smart materials for smart sustainable urbanization.

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Abstract
Urban areas are formed by buildings and many other types of structures. Smart and sustainable structures in this regard are required for smart sustainable urbanization, to be consistent with the progressive development of the world. Materials possessing a capability of adapting themselves with their environment, either in passive or active conditions, are known as smart materials and capable of bringing smartness into our structures. There are different types of smart materials that can be utilized in the construction of structures. Shape Memory Alloys (SMAs), fiber optics, piezoelectric materials, Magneto-Rheological (MR) fluids, Electro-Rheological (ER) fluids and magnetostrictive materials are the promising examples of smart materials that deserve increasing interest in civil engineering applications. Innovative applications of these materials in construction industry are investigated in this paper. Brief descriptions of the physical principles are provided, and the proof of concept demonstrations are presented. Advantages and limitations of the implementation of each material in civil structures are defined and the effectiveness of passive systems are discussed. It is concluded that SMAs are the best candidates among the available smart materials that can be used for earthquake-resistant design of structures. The suitability of SMAs as aseismic devices is then verified experimentally. It is also shown that materials with damping and stiffness properties changing by changes in stress/strain and/or acceleration are similarly useful for the purpose of earthquake protection of structures. Production and application of these types of smart materials, however, require further research but seems to be more attractive in the civil engineering profession.

Keywords: Smart Materials; Sustainable Urbanization; Civil Structures; Earthquake Protection; Aseismic Devices.
Abstract
Global ethanol production generates 900 to 2000 billion liters per year of a high-strength liquid waste called vinasse. Vinasse represents a substantial renewable energy resource, through anaerobic digestion to produce biogas. Although a variety of previous studies have measured biogas generation from anaerobic treatment of vinasse, no previous study has developed a general model to predict biogas production from anaerobic digestion of vinasse of any composition at a range of temperatures (mesophilic). The aim of this research was thus to build a first-order model VUMP (Vinasse Utilization for Methane Production) to predict methane generation from anaerobic treatment of vinasse from ethanol production, based on readily available inputs of initial vinasse composition and treatment temperature. Lab-scale anaerobic digesters were filled with 4 synthetic vinasse mixtures with differing initial values of chemical oxygen demand, nitrogen, potassium, phosphorous, and sulfur, operated at 3 temperatures each, for a total of 12 reactors. Based on data collected, a multiple linear regression equation ($R^2 = 0.80$) was developed to predict first-order methane generation rate constant $k$. The selected best-fit model for $k$ varied positively as functions of temperature, initial chemical oxygen demand, and the product of nitrogen and phosphorous. Preliminary validation indicated that the model predicted methane generation from commercial vinasse within 20%.

Keywords: Anaerobic Digestion, Biogas, Ethanol, Methane.