ABSTRACT
Small engines, such as conventional two-stroke engines used in marine outboards and personal watercraft (PWC), are high polluters relative to their engine size and usage. Porous structures based on zeolites show promising characteristics as washcoat materials on cordierite ceramics for tail pipe exhaust emission control. This study reports the characterization of commercial grades of zeolites (Ammonium form of ZSM-5, Zeolite Y and Mordenite) and several transition phases of these zeolites aiming at their use as environmental washcoat materials. Thermogravimetry, X-ray diffraction, specific surface area and electron microscopy were used to characterize the zeolites. ZSM-5 shows high thermal and structural stability compared to the other zeolites investigated. As porogenic and increased active site agents, the transition phases showed a large quantity of meso-macro pores and a variation in the specific surface areas of the zeolites still large enough, which highlights their potential to be used in environmental catalysis.

KEY WORDS: Zeolite; transition phases; specific surface area; functional coating; porogenic; structural stability; thermal stability

INTRODUCTION
Application of catalytic converters in two-stroke engines based on zeolite washcoat is becoming one of the most realistic methods of decreasing the levels of exhaust gas emissions. Zeolites are important in view of their industrial applications, such as in ion exchange, as molecular sieves, catalysts and adsorbents. Zeolites are unique crystalline compounds containing uniform sized micropores in their crystal structures. They show excellent cation exchange capacities, strong solid acidities, high adsorbing abilities and molecular sieving properties (Tominaga, 1993). Zeolite catalysts can be extruded or coated onto metal or ceramic substrates. The coating process involves preparation of zeolite slurry using a binder, usually colloidal silica or alumina, dipping the monolith, then drying and firing.

Various zeolites such as ZSM-5 (Seijger et al 2001; García-Martínez et al, 2001; Basaldella et al, 2002; Ulla et al, 2003; Ohman et al, 2004) and Mordenite (Ulla et al, 2004) have been successfully coated on supports by the in situ hydrothermal synthesis method. Moreover, in situ synthesized monolithic zeolite/support and modified zeolite/support have proven to be successful catalysts for many important reactions (van der Puil et al, 1996; Oudshoorn et al, 1999; Basaldella et al, 2002; Li et al, 2004; Li et al, 2005). Currently, the study of in situ synthesis focused on the optimized preparation of zeolite coatings (mainly ZSM-5) on various supports, such as honeycomb cordierite (Ulla et al, 2003; Ohman et al). Li et al, (2005) in their study explored a series of zeolites (Linde A, Linde Y, Mordenite and ZSM-5) which were synthesized on honeycomb cordierite supports by an in situ hydrothermal method in the absence of organic templates or zeolite seeds. They suggested that such a simple synthesis system would provide a better understanding of the growth of zeolites on supports.

Therefore the objective of this paper is to characterize commercial grade zeolites to predict which has more suitable properties for use as environmental materials. This is inspired by the development of ultra-stable type zeolites with much improved thermal and hydrothermal stability, and such zeolites show good potential for their use as washcoat materials.

MATERIALS AND METHODS
Ammonium form of zeolites procured from Zeolyst Inc, USA was characterized by the thermo gravimetric /differential scanning calorimetry (TG/DSC), X-ray diffractometer (XRD), scanning electron microscopy (SEM) and BET- specific surface area analyzer. The as-received zeolites were first characterized by the TG/DSC (ramped from 200°C –1000°C) and XRD to ascertain their thermal and structural stability before being calcined at 600°C and 900°C. The thermal conditions chosen for the calcination of zeolite samples was guided by