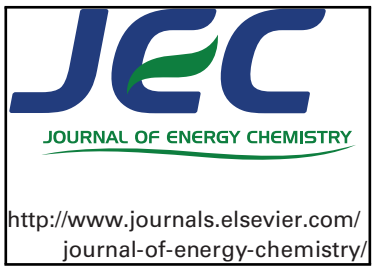

A new, sustainable process for synthesis of ethylene glycol

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A new, sustainable process for synthesis of ethylene glycol

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In conventional heterogeneous catalytic process, the activation of C−H bond remains grand challenge. It is even more difficult to activate the inert C−H bond with other functional groups (e.g. OH) in the same molecule keeping intact [1]. Although the transformation of C_1 species (e.g. CO, CO_2, CH_4 and CH_3OH) into C_2 molecules (e.g. C_2H_4, C_2H_5OH and $HOCH_2CH_2OH$) via C−C coupling has been a hot research topic but the yield of aimed product is still needed to be improved. Ethylene glycol (EG) is a versatile chemical with many important applications, in particular for the manufacture of polyesters, predominantly poly(ethylene terephthalate) (PET) [2]. Recently, Wang, Deng and coworkers at Xiamen University cleverly designed a new process for the conversion of methanol to ethylene glycol (MTEG), in which the EG selectivity can reach 90% (Eq. 1) [3].

$$2CH_3OH \rightarrow HOCH_2CH_2OH + H_2 \quad (1)$$

In order to promote the performance of catalysts and overcome the thermodynamic limitation of chemical reactions, many investigations have been conducted by applying an external field, such as light, voltage or magnetism in catalytic systems. For example, the solar energy-driven photochemistry has attracted much attention for the degradation of organic pollutants, the splitting of water and the reduction of CO_2, but the studies on photocatalytic C−H activation and C−C coupling of small molecules are rare. Previously, it has been found that HCHO could undergo reductive coupling to EG under visible-light irradiation over $BiVO_4$ catalyst, while the EG selectivity was low (~40%) [4,5]. In contrast to the reduction of aldehyde, photocatalytic coupling of CH_3OH to EG is of more scientific significance because of the high challenging feature of preferential activation of C−H bond. In addition, methanol is an abundant and cheap C_1 building block that can be derived from a variety of carbon resources including coal, natural or shale gas, biomass and even CO_2 [6]. Therefore, the MTGE process would offer an atom-efficient and non-petroleum sustainable EG production approach.

However, photocatalytic conversion of CH_3OH over most semiconductor photocatalysts, such as TiO_2, ZnO and g-C_3N_4 only produces HCHO, HCOOH and CO/CO_2 instead of EG [7]. It has been generally thought that the O–H bond is easier to activate. Therefore, it is important to find a semiconductor with "unusual property" for the preferential activation of C-H bond. Olaf discovered that CdS is unique for the formation of EG under visible light, though the efficiency of CdS alone for EG formation remains low [6]. This is quite surprising because CdS is a conventional semiconductor used in many photocatalytic reactions.

Subsequently, Deng et al found an efficient co-catalyst, MoS_2 nanofoams, which can promote the EG formation significantly. The new structured MoS_2 nanofoams exhibit excellent H_2 evolution activity in electrochemical process [3]. By adding a small amount of MoS_2 foams with rich edge sites onto CdS nanorods (Fig. 1), they found more than 20 times enhancement in the EG formation efficiency. MoS_2 foams can not only effectively promote the transfer of electrons and generate photogenerated holes on the surface of CdS, but also