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[[A]A405-1vn] 21. Energy and Related Chemistry, Geo and Space Chemistry

Chair: Nobuto Oka, Takaya Kubo

Japanese
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Highly stable and efficient photoelectrochemical water oxidation at an anisotropically crystallized monoclinic WO_3 film with predominant growth of (202) plane

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[[A]A405-1vn-02]

Atmospheric methane as an indicator of earthquake generation

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Highly stable and efficient photoelectrochemical water oxidation at an anisotropically crystallized monoclinic WO_3 film with predominant growth of (202) plane

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Keywords: Tungsten oxide; Water splitting; Photoanode; Photoelectrocatalyst

An anisotropically crystallized monoclinic WO_3 films were synthesized on fluorine-doped tin oxide (FTO) electrode by a one-step hydrothermal method using oxalic acid (Oxa) as a structure directing agent. The WO_3 film (denoted as WO_3(*w*-Oxa)) prepared with Oxa was composed of relatively large layered-sheets with 2 ~ 5 μm length with predominant growth of the (202) plane (parallel to the substrate), in contrast to small layered-sheets with 1 ~ 2 μm length with predominant growths (020) or (200) planes for the WO_3(*w/o*-Oxa) film prepared without Oxa. Although the photocurrents were generated above 0.6 V vs. RHE for WO_3(*w*-Oxa) and WO_3(*w/o*-Oxa) electrodes, the incident photon to electron conversion efficiency ($IPCE_{420}$ = 38%) at 420 nm and 1.23 V vs RHE for the former was 2.7 times higher than that (14%) of the latter. The higher $IPCE_{420}$ for the WO_3(*w*-Oxa) is ascribed to higher charge separation (η_{sep} = 50 %) and catalytic (η_{cat} = 95 %) efficiencies compared to those (η_{sep} = 19 % and η_{cat} = 82 %) for the WO_3(*w/o*-Oxa) electrode. The photoelectrochemical impedance spectroscopic (PEIS) measurement suggested effective bulk charge transport in the WO_3(*w*-Oxa) electrode compared to the WO_3(*w/o*-Oxa) electrode, which works to the advantage of suppressed recombination of photogenerated charges (electrons and holes), being responsible for the higher η_{sep}, eventually causing the higher IPCE for the WO_3(*w*-Oxa) electrode. The WO_3(*w*-Oxa) electrode showed the high photocurrent stability (95% remain for 7 h) and Faraday efficiency (FE_{O2}) of 95% for water oxidation. The high stability and FE_{O2} of the WO_3(*w*-Oxa) electrode result from the suppression of the competed photo-oxidation of the surface by the attenuated hole accumulation due to efficient water oxidation at the (202) facet surface.

地震発生の指標としての大気中メタン

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Atmospheric methane as an indicator of earthquake generation

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Relationship between atmospheric methane (a greenhouse gas) and earthquake was examined in this study. The data of surface-level methane were obtained from the Atmospheric Environmental Regional Observation System, managed by the Ministry of Environment, Japan. Approximately 500 monitoring sites are located from Hokkaido to Kagoshima prefectures, Japan. There was a clear relation between the increase of atmospheric methane concentration and the generation of individual earthquakes (Magnitude ≥5.0) during 2010-2024 in Japan. In Tohoku region Pacific side, Minami-Kanto region, Hokuriku region and Kyushu region, atmospheric methane concentration largely increased immediately after occurrence of big earthquakes such as M9.0 Great East Japan Earthquake (3/11/2011), M7.3 Kumamoto Earthquake (4/16/2016), M7.4 Fukushima off coast Earthquake (3/16/2022) and M7.6 Noto Peninsula Earthquake (1/1/2024). In these regions, water-dissolved natural gas fields are widely distributed. Methane was supposed to release from natural gas fields into atmosphere when earthquake occurs. In conclusions, atmospheric methane can be an indicator of earthquake generation. Earthquake should be considered a major source of atmospheric methane in earthquake-prone countries like Japan. Moreover, methane hazards such as fire and explosion should be warned in natural gas field regions when earthquake occurs.

Keywords : Atmospheric methane, Earthquake, Indicator of earthquake generation, Natural gas field

本研究において、地球温暖化に関与する大気中メタンと地震との関連性について調べた。地表面レベルのメタン濃度データは、環境省大気汚染物質広域監視システムから入手した。この大気汚染監視システムは、北海道から鹿児島まで全国で約 500 のメタン測定局を有する。結果、2010 年～2024 年の 15 年間に日本で発生した地震（マグニチュード 5 以上）と大気中メタン濃度との間に関連性があることが示された。M9.0 東日本大震災(2011.3.11)、M7.3 熊本地震(2016.4.16)、M7.4 福島沖地震(2022.3.16)、M7.6 能登半島地震(2024.1.1)などの大地震の発生直後に、震央に近い東北地方太平洋側、南関東地方、北陸地方、九州地方などの地域でメタン濃度が大きく増加した。これらの地域には、水溶性ガス田（天然ガスが地層中の地下水に溶解した状態で存在する地域）が広く分布する。地震の直後に、ガス田のメタンが大気中に放出されたと考えられる。結論として、大気中メタンは地震発生の指標として用いることができる。日本のように地震が多発する国では、地震を大気中メタンの主要な発生源の一つとして考慮すべきであろう。また、ガス田が存在する地域では、地震発生時に火災や爆発などのメタン災害への警戒が必要であろう。