

原著論文

水性形接着剤から放散される化学物質による 室内汚染濃度の予測

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Estimation of Indoor Air Pollution by VOCs and Aldehydes Emitted from Water-Based Adhesive

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要 旨

近年需要が増加している水性形接着剤から、塗布時に放散される VOC 及びアルデヒド類を調査した。市販の一般家庭向け製品 6 種について、塗布後 24 時間中に放散する化学物質を測定したところ、酢酸、ブタノール、酢酸ビニルモノマー、酢酸エチル、グルタル酸ジメチル、3-メチル-3-メトキシブタノール (MMB)、ブトキシエトキシエタノール、ウンデカン、ドデカン、ホルムアルデヒド、アセトアルデヒド等が検出された。また、酢酸ビニル樹脂系接着剤が学校教材として汎用されていることに着目し、接着剤塗布直後から 24 時間後までの化学物質放散量を小型チャンバー法により測定し、教室内の濃度推移を試算した。検出された主な物質及びモデル化により求められたそれらの初期放散速度は、MMB $183 \pm 31.0 \text{ mg/m}^2/\text{hr}$ 、酢酸 $164 \pm 42.0 \text{ mg/m}^2/\text{hr}$ 、酢酸ビニルモノマー $24.0 \pm 2.4 \text{ mg/m}^2/\text{hr}$ 、ホルムアルデヒド $0.54 \pm 0.07 \text{ mg/m}^2/\text{hr}$ 、アセトアルデヒド $0.92 \pm 0.25 \text{ mg/m}^2/\text{hr}$ であった。教室内濃度の試算では (換気回数 2.2 回)、接着剤塗布によるホルムアルデヒド及びアセトアルデヒドの濃度上昇は最大で約 $1 \mu\text{g/m}^3$ であったが、VOC では検出された 6 物質の合計値が $670 \mu\text{g/m}^3$ と算出され、厚生労働省の TVOC 目標値 ($400 \mu\text{g/m}^3$) を超えていた。放散が認められた主な物質について製品中の含有量を測定したところ、MMB 5.8 mg/g 、酢酸 3.2 mg/g 、酢酸ビニルモノマー 0.020 mg/g 、ホルムアルデヒド 0.017 mg/g 、アセトアルデヒド 0.007 mg/g であった。

Abstract

The annual production of water-based adhesives has increased in recent years. However, there are few reports about the chemicals emitted from water-based adhesives. To investigate volatile organic compounds (VOCs) and aldehydes emitted from water-based adhesive, six adhesive products sold for domestic use were dried in a Tedlar[®] Bag for 24 hours, then the air in the Tedlar[®] Bag was analyzed by gas chromatography/ mass spectrometry (GC/MS) and high-performance liquid chromatography (HPLC). The predominantly detected compounds were acetic acid, 1-butanol, vinyl acetate, ethyl acetate, dimethyl glutarate, 3-methyl-3-methoxybutanol, 2-(2-butoxyethoxy)ethanol, undecane, dodecane, formaldehyde, and acetaldehyde.

Polyvinyl acetate adhesive, which is one of the most commonly used water-based adhesives, is commonly used for arts and crafts lessons in elementary schools. To estimate indoor air pollution by polyvinyl acetate adhesive in a classroom, the temporal change of VOCs and aldehydes concentration emitted from newly applied polyvinyl acetate adhesive were measured by the small chamber test method. An exponential equation was then developed to evaluate the emission parameters of VOCs and aldehydes. The compounds detected in the chamber and their model-derived primary emission rates were 3-methyl-3-methoxybutanol at $183 \pm 31.0 \text{ mg/m}^2/\text{hr}$, acetic acid at $164 \pm 42.0 \text{ mg/m}^2/\text{hr}$, vinyl acetate at $24.0 \pm 2.4 \text{ mg/m}^2/\text{hr}$, formaldehyde at $0.54 \pm 0.07 \text{ mg/m}^2/\text{hr}$ and acetaldehyde at $0.92 \pm 0.25 \text{ mg/m}^2/\text{hr}$. For calculations the indoor environment in the classroom was defined as volume = 192m^3 , air change rate = 2.2/hr, number of students in the class = 40 and adhesive application area = 300cm^2 per student. The estimated maximal concentration increase obtained by applying the polyvinyl acetate adhesive was about $1 \mu\text{g/m}^3$ for formaldehyde and acetaldehyde, and about $670 \mu\text{g/m}^3$ for the total VOCs detected. The concentrations of predominantly detected VOCs and aldehydes in the polyvinyl adhesive were 5.8 mg/g for 3-methyl-3-methoxybutanol, 3.2 mg/g for acetic acid, 0.017 mg/g for formaldehyde and 0.007 mg/g for acetaldehyde.

Key words: water-based adhesive, polyvinyl acetate adhesive, aldehyde, volatile organic compound, emission rate, indoor air