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硕士学位论文

楚科奇海和大亚湾胶体有机物的组成和粒径分布—非对称流场场流仪的应用

Composition and size distribution of colloidal organic matter in the Chukchi Sea and Daya Bay: Application of asymmetric flow field-flow fractionation

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摘要

本研究对非对称流场场流仪分离、测量海水中胶体有机物的方法进行了摸索和优化,并通过两个夏季航次的采样和分析,首次开展了楚科奇海和大亚湾胶体有机物光学性质及其粒径分布的研究,进而揭示楚科奇海和大亚湾胶体有机物的来源、组成等信息,获得如下主要认识:

(1) 建立了非对称流场场流仪分离、测量海水胶体有机物的方法,优化了样品进样体积,确定了以 0.9% NaCl 溶液作为分离海水胶体物质的载液;通过多次重复试验确定了最佳的粒径分离方案,评估了光学探头检测平行性、精密度和检出限;确定了采用蛋白类物质作为粒径校正的标准物质,可较准确地获得天然海水胶体有机组分的分子量。

(2) 首次开展了楚科奇海胶体有机物光学性质及其粒径分布的研究,发现三种粒径大小的胶体有机物(1~10 kDa、10~100 kDa 和 >100 kDa) 均与海水中的河水组份份额呈现良好的线性正相关关系,且随着粒径的增加,相关关系有所减弱,证明楚科奇海胶体有机物主要来自陆源输入,而且小分子量组份受陆源输入的影响更为显著。此外,吸光系数 a_{254} 是楚科奇海指示陆源有机物输入的良好指标。

(3) 夏季大亚湾海域的 CDOM 含量呈现出湾内高,湾外低的空间分布规律。根据三维荧光光谱的分析结果,大亚湾胶体态 CDOM 的来源主要来自陆源输入、人类排放和当地生物生产过程,其中陆源输入占 50.1%,人类排放输入占 32.8%,生物生产贡献 17.1%。因此,尽管大亚湾是一个生产力较高的沿岸海域,但其有机物还是以陆源输入和人为输入为主。当地生物生产提供的类蛋白组份虽然只占荧光有机物的 17%,但它对大亚湾海域 DOC 的空间变化有较大的影响,导致在大亚湾海域并未观察到 CDOM a_{254} 与 DOC 浓度之间的线性正相关关系,与其他很多海域不同。因此,CDOM a_{254} 不适宜作为指征大亚湾 DOC 变化的指标。另外,大亚湾 CDOM 光谱斜率 ($s_{210-260}$) 与胶体态 CDOM 分子量之间不存在显著的相关关系,因而光谱斜率 ($s_{210-260}$) 也无法反映大亚湾有机组分的粒径

变化。

关键词：非对称流场场流仪；有色溶解有机物；胶体有机物；楚科奇海；大亚湾

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Abstract

The separation and analysis method for marine organic colloids by Asymmetric Flow Field-Flow Fractionation (AF4) was optimized in this study. The properties and size spectra of colloidal organic matter in the Chukchi Sea and the Daya Bay in summer were firstly studied for elucidating the source and composition of colloidal organic matter. The main conclusions were obtained as follows.

(1) The separation and analysis method for marine colloidal organic matter by AF4 was set up with the injected volume being optimized and a solution of 0.9% NaCl used as a carrier. After a series of pre-experiments, proteins with macromolecules were used as the standards to calibrate size spectra of marine colloidal organic matter. Additionally, the repeatability and detection limit of our method were assessed.

(2) All of the integrated CDOM UV_{254} of three fractions (1~10 kDa, 10~100 kDa, >100 kDa) showed significant correlation with the fraction of meteoric water (f_{mw}), and the correlation coefficients decreased with the increasing molecular weights, which indicated the CDOM in the Chukchi Sea was mainly terrigenous and the smaller colloids were more influenced by terrestrial input. Additionally, CDOM a_{254} is a potential good tracer for terrigenous dissolved organic matter in the Chukchi Sea.

(3) The spatial distribution of CDOM showed a offshore decrease in the Daya Bay in summer. The colloidal CDOM was mainly input from terrestrial, anthropogenic and *in situ* production based on the fluorescent EEMs, with fractions of 50.1%, 32.8% and 17.1% for the terrestrial input, anthropogenic discharge and *in situ* production, respectively. Although the *in situ* production contributed only 17% of fluorescent DOM, it influenced the CDOM distribution, and broken the linear correlation between a_{254} and DOC in the Daya Bay. Therefore, CDOM a_{254} is not

suitable for tracing DOC in the Daya Bay. The spectral slope ($s_{210-260}$) showed no significant correlation with the molecular weights of CDOM in the Daya Bay, which ruled out the possibility to use spectral slope ($s_{210-260}$) as an indicator of size change of colloidal organic matter in the Daya Bay.

Key Words: Asymmetric flow field-flow fractionation; Chromophoric dissolved organic matter; Colloidal organic matter; Chukchi Sea; Daya Bay

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缩略词

缩略词	全称	中文名
BSA	Bovine Serum Albumin	牛血清蛋白
CDOM	Chromophoric Dissolved Organic Matter	有色溶解有机物
DIC	Dissolved Inorganic Carbon	溶解无机碳
DOC	Dissolved Organic Carbon	溶解有机碳
EEMs	Excitation-Emission Matrices	荧光矩阵光谱
FDOM	Fluorescence Dissolved Organic Matter	荧光溶解有机物
FFF	Field Flow Fractionation	场流仪
FTIR	Fourier Transform Infrared Spectroscopy	傅里叶变换红外谱
kDa	kilo-Dalton	千道尔顿
LDOM	Labile Dissolved Organic Matter	易降解溶解有机物
M.W.	Molecular Weights	分子量
NMR	Nuclear magnetic resonance spectroscopy	核磁共振谱
PARAFAC	Parallel Factors Analysis Program	平行因子分析程序
POM	Particulate Organic Matter	颗粒有机物
PSS	Polystyrene Sulfonate	聚苯磺乙烯
RDOM	Refractory Dissolved Organic Matter	难降解溶解有机物
RO/ED	Reverse Osmosis-Electro-Dialysis	反渗透-电渗析
SPE	Solid-Phase Extraction	固相萃取技术
TOC	Total Organic Carbon	总有机碳
$s_{275-295}$	Spectrum slope between 275 nm and 295 nm	275 nm-295 nm 之间的 光谱斜率
s_R	Slope ratio at $s_{275-295}$ and $s_{350-400}$	斜率比值
VB ₁₂	Vitamin B ₁₂	维他命 B ₁₂

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