



PROPOSAL FOR the Alternative Fuel Vessel

Presented by SOx-Free, NOx-Free

INDEX

- Background
- Problem and Basis
- Proposal to IMO
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nature

"THE DIRTY TEN"

RESEARCH | REPORTS

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SOLAR CELLS

Particulate Matter less than 2.5 micrometres (PM2.5) emitted from dirty marine fuel oil causes poor air quality along shipping lanes. Emissions-Control Zones omit the ten largest container ports, which contribute an estimated 20% of worldwide port emissions of nitrogen oxides(Nox) and sulfur oxides(SOx)

Source : Nature (2016.02)

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SUPPLEMENTARY MATERIALS

www.sciencemag.org/content/345/6240/5230/suppl/DC1
Materials and Methods
Figs. S1 to S17
Tables S1 to S2
References (39–52)
8 February 2015; accepted 4 May 2015
10.1126/science.1258765

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methodologies (4–6) and computational engineering of perovskite materials (7–9) over the past 3 years have led to rapid improvements in the power conversion efficiency (PCE) of perovskite solar cells (PSCs). Although solar-to-electric PCEs of up to 18% have been reported for PSCs (10), developing technologies further to achieve PCEs near theoretical values (>30%) continues to be an important challenge in making the solar cell industry economically competitive. Formamidinium lead iodide (FAPbI₃) is a perovskite material that can potentially provide better performance than methylammonium lead iodide (MAPbI₃) because of its broad absorption of the solar spectrum. In addition, FAPbI₃ with the n-p architecture (the n-side is illuminated with solar radiation) exhibits negligible hysteresis with sweep direction during current-voltage measurements (8–13). However, it is more difficult to form stable perovskite phases and high-quality films with FAPbI₃ than with MAPbI₃.

[†]Division of Advanced Materials, Korea Research Institute of Chemical Technology, 341 Gajong-Ro, Yuseong-Gu, Daejeon 305-380, Korea. [‡]Department of Energy Science, Sungkyunkwan University, Suwon 440-746, Korea.

*These authors contributed equally to this work. †Corresponding author. E-mail: seokil@kriect.re.kr

deposition (14), solution-solvent deposition (15), and vacuum evaporation (16) can now produce high-quality films of MAPbI₃ with flat surfaces and complete surface coverage by controlling its rapid crystallization behavior and have led to substantial improvements in the PCE of MAPbI₃-based PSCs.

Among these methodologies, two-step sequential deposition and solvent engineering are representative wet processes that can yield perovskite films for high-performance PSCs. In the sequential deposition process, a thin layer of PbI₂ is deposited on the substrate; methylammonium iodide (MAI) or formamidinium iodide (FAI) is then applied to the predeposited PbI₂ to enable conversion to the perovskite phase. This process involves crystal nucleation and growth of the perovskite phase because of solution-phase or solid-state reaction between PbI₂ and an organic iodide such as MAI or FAI (4, 13, 17, 18). However, the sequential reaction of organic iodides with PbI₂ that occurs from the surface to the inner crystalline regions of PbI₂ has been ineffective in producing high-performance perovskite films that are >500 nm in thickness because of incomplete conversion of PbI₂, peeling off of the perovskite film in solution, and uncontrolled surface roughness. In contrast, the solvent-engineering process uses the formation of intermediate phases to

Table 1. Comparison of layer thickness before and after FAPbI₃ phase is formed by conventional and intramolecular exchange process (IEP). The thin PbI₂ and PbI₂(DMSO) layers were deposited on a fused quartz glass, and their layer thickness was measured by alpha-step IQ surface profiler.

Method	Before	After
Conventional process (PbI ₂)	290 nm	570 nm
IEP [PbI ₂ (DMSO)]	510 nm	560 nm

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Percentage of Vessel in Worldwide Emission



SOx

5~8%

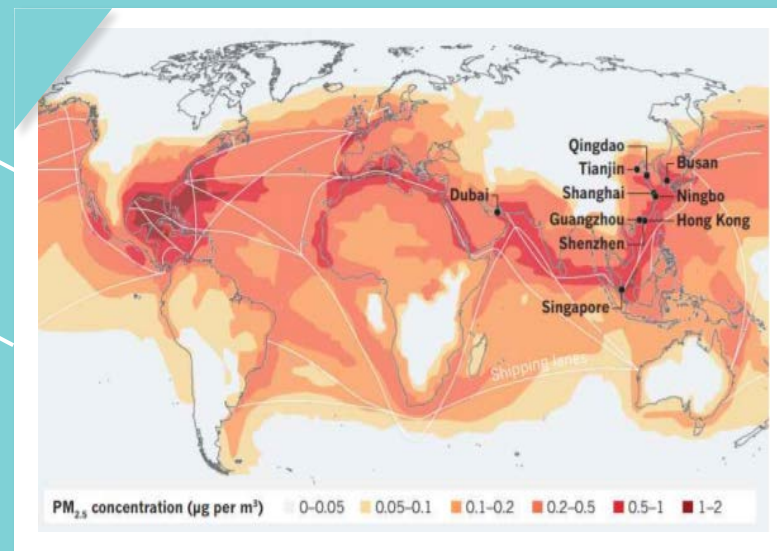
NOx

15%

The concentration of ultrafine dust (PM_{2.5}) is high around the world's major shipping routes.

Low-grade marine fuel oil contains 3,500 times more sulfur than road diesel.

Regulations must be made and strengthened
Against the Emission of Vessels



The regulations for the Prevention
of Emissions from Vessels



MARPOL 73/78 Annex VI



SOx Regulation
Regulation 14.



NOx Regulation
Regulation 13.



ECA(Emission Control Area)

Tier	Ship construction date on or after	Total weighted cycle emission limit (g/kWh) n = engine's rated speed (rpm)		
		n < 130	n = 130 - 1999	n ≥ 2000
I	1 January 2000	17.0	$45 \cdot n^{(-0.2)}$ e.g., 720 rpm – 12.1	9.8
II	1 January 2011	14.4	$44 \cdot n^{(-0.23)}$ e.g., 720 rpm – 9.7	7.7
III	1 January 2016	3.4	$9 \cdot n^{(-0.2)}$ e.g., 720 rpm – 2.4	2.0

Outside an ECA established to limit SOx and particulate matter emissions

Inside an ECA established to limit SOx and particulate matter emissions

4.50% m/m prior to 1 January 2012

1.50% m/m prior to 1 July 2010

3.50% m/m on and after 1 January 2012

1.00% m/m on and after 1 July 2010

0.50% m/m on and after 1 January 2020*

0.10% m/m on and after 1 January 2015

"Implementation of the Global Sulphur limit!"

New Global Limit

0.5% m/m global limit of the sulfur content of fuel oil, which will come into effect from 1 January 2020.



How can ships meet lower Sulfur emission standards?

Method 1

Low Sulfur Fuel Oil

A method to refine the existing fuel containing a large amount of sulfur once more and make it less than 0.5%

Examples

Maersk Line, etc

Method 2

Scrubbers

A method that uses the existing fuel and captures, removes SO_x before they are released into atmosphere

Examples

Hyundai Line, etc

Method 3

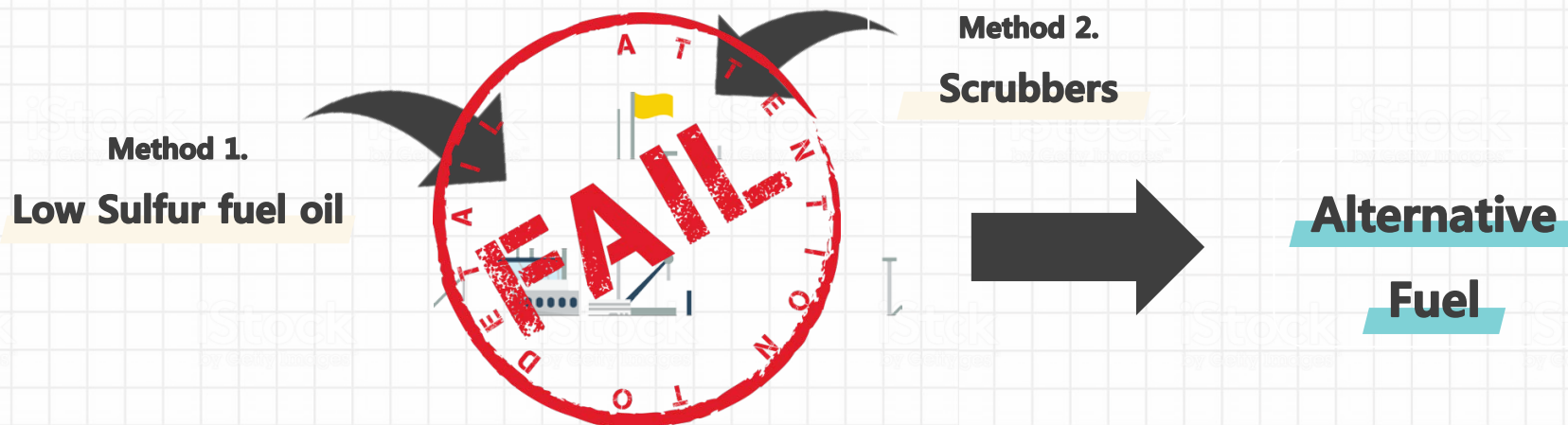
Alternative Fuel

Since alternative fuels essentially contain very little impurities, SO_x, PM is rarely released

Examples

No case

However, Only alternative fuels meet the Original Purpose of Regulation

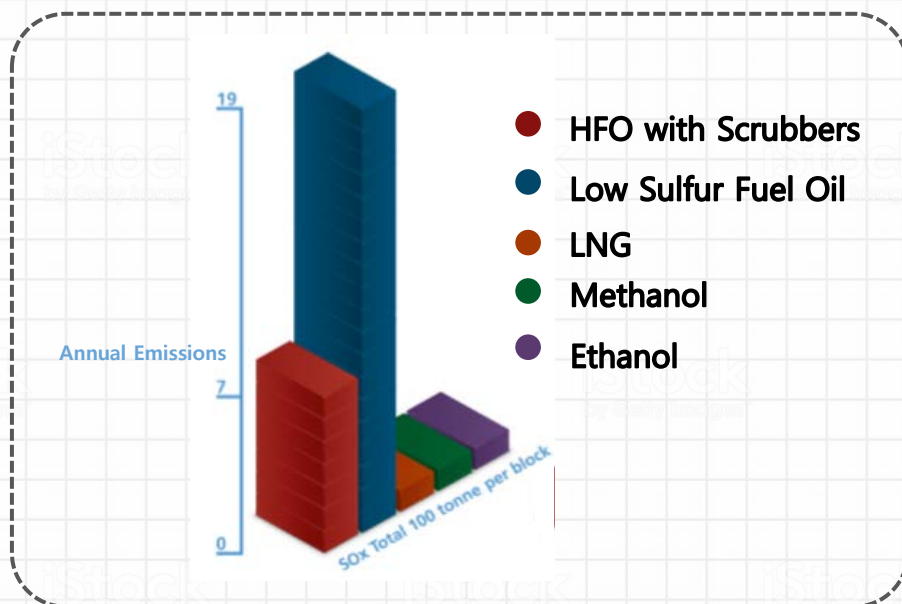


The original purpose of the MARPOL 73/78 Annex VI is to make Vessel Emissions **ZERO** over the long term

Low Sulfur Fuel oil and Scrubber are only short-term alternatives to take action against the 2020 SOx regulation

For the original purpose, ' Alternative fuels ' should be used on Vessels

Why only alternative fuels meet the original purpose of Regulation



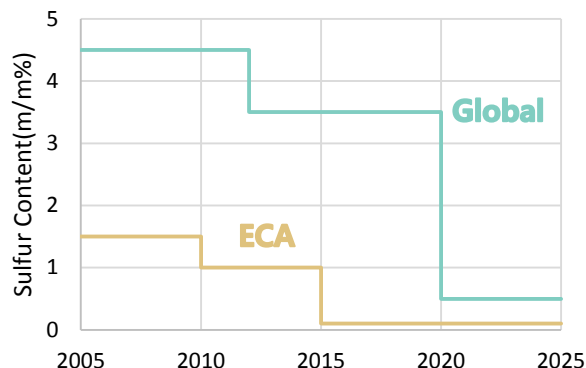
Compared to alternative fuels, scrubbers produce SOx 7 times and low sulfur fuel oil 19 times

Two methods of responding to the Regulation 14 can meet the conditions of 0.5 %, but SOx emissions are still significant.

- Scrubbers and Low Sulfur Fuel Oil consider only the 2020 regulation and these are short-term alternatives.

The two methods never fit original purpose of IMO

Increasingly strengthened Regulations



- MEPC 58, **revisions to progressively reduce pollutants.**

- Marine fuel sulfur content

• **Global:** 4.5% → 3.5% → 0.5%

ECA: 1.5% → 1.0% → 0.1%

After 2020???

Expanding of ECA

2006 - the Baltic Sea area

2007 - the North Sea area

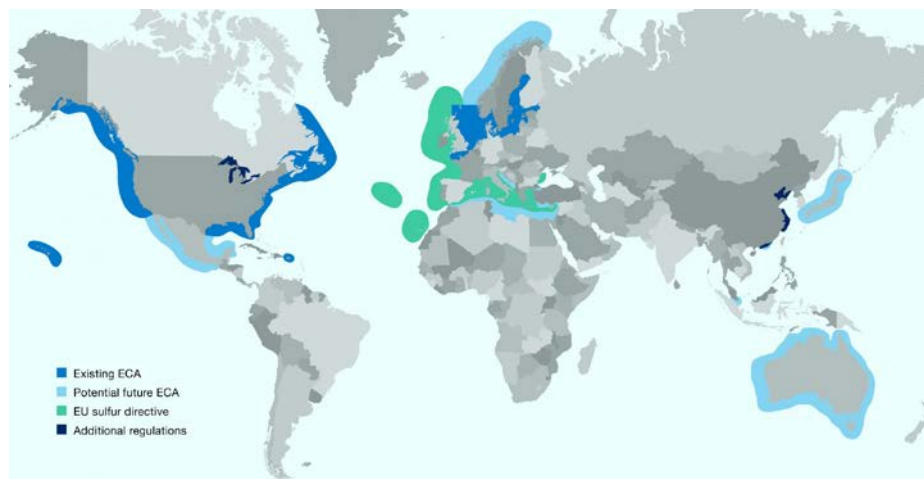
2014 - the North American area

the United States Caribbean Sea area

2019 - Circum-Bohai-Sea, Yangtze River Delta,
Pearl River Delta, China

Potential Future ECA

Australia, Japan, Korea, Mexico, and in the
Mediterranean Sea.



Why only alternative fuels is the answer

Method 1.

Low Sulfur fuel

- The price of Low Sulfur Fuel (0.5 % sulfur) is 40 % to 60 % higher
- The Low Sulfur Fuel price will continuously rise along with regulations
- The use of **Low Sulfur Fuel oil cause economic losses**

Method 2.

Scrubbers

- Vessels have a very long life about 30 years
- The Sulfur regulation are revised twice during 13 years
- **Scrubber cannot be a long-term solution**

The two methods are not appropriate in the long term

Why only alternative fuels is the answer

Interview.

A1. The fundamental purpose of strengthening global SOx Cap regulation was to **gradually reduce the use of fossil fuels and encourage the use of alternative fuels** after 2020



A2. Scrubber and low-sulfur fuel have **limitations which meet only the Global SOx Cap regulations that begin in 2020.**

Reasons why the original purpose of regulation is not observed



Because the purpose is unclear ✖

New Proposal

Add the 'Purpose of Legislation' on MARPOL Annex VI

ANNEX

REVISED MARPOL ANNEX VI

Regulations for the Prevention of Air Pollution from Ships

CHAPTER I

GENERAL

Regulation 1
Application

The provisions of this Annex shall apply to all ships, except where expressly provided otherwise in regulations 3, 5, 6, 13, 15, 16 and 18 of this Annex.

0. "In the long term, the vessel emission pollutants should be zero"

A detailed amendment is necessary to induce a

New Direction

Regulation 10

Port State Control on Operational Requirements

1 A ship, when in a port or an offshore terminal under the jurisdiction of another Party, is subject to inspection by officers duly authorized by such Party concerning operational requirements under this Annex, where there are clear grounds for believing that the master or crew are not familiar with essential shipboard procedures relating to the prevention of air pollution from ships.

2 In the circumstances given in paragraph 1 of this regulation, the Party shall take such steps as to ensure that the ship shall not sail until the situation has been brought to order in accordance with the requirements of this Annex.

3 Procedures relating to the port State control prescribed in article 5 of the present Convention shall apply to this regulation.

4 Nothing in this regulation shall be construed to limit the rights and obligations of a Party carrying out control over operational requirements specifically provided for in the present Convention.

+ in the ports where the number of LNG ships account for more than 10% of the total ships entering and leaving ports, it is mandatory to review and discuss the introduction of alternative fuel bunkering facilities.

+ By 2050, the portion of alternative fuel vessels should be over 50% of all vessels

New

MEPC 58/23/Add.1
ANNEX 13
Page 13

The simultaneous regulation of
Vessels and Ports



Can fulfill the original purpose of regulation

If there is a Clear Purpose of Regulation, it can make **Win-Win** relation between each other.

Regulator



Win-Win



Regulated Subjects



- The regulator will be satisfied that the purpose of regulation can be correctly fulfilled

- Do not come up the countermeasures in the short-term
- Know the future in advance and be able to act

The alternative fuel which is the most effective for reducing ship emission air pollutants

The Vessel Emission could be Zero

Thank You