Performance Assessment System for AkzoNobel Fouling Control Product

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1. Introduction

Marine biofouling, the unwanted colonization of marine organisms on underwater surfaces, poses serious challenges to vessel efficiency and environmental sustainability. This study, conducted in collaboration with AkzoNobel International Paint Limited, comprehensively assesses the performance of various fouling control coatings. Our goal is to offer practical insights into the performance of 11 coatings on 9 routes across 3 activity groups, optimizing strategies for enhanced vessel efficiency. Through quantitative and qualitative assessment, we contribute to informed decision-making within the antifouling coatings industry. This endeavor aligns with efforts to improve vessel efficiency, reduce emissions, and minimize the impact of biofouling in marine environments.

2. Data

- **Data Description:** The dataset provided by AkzoNobel comprises 11,216 records and 10 variables, offering insights into vessel profiles and coating performance. Key variables include *Scheme Group* (in months) categorized as 0-36, 37-60, *Route Number* (9 options), *Activity Group* (0-30%, 31-60%, 61-100% activity levels), *Product Code* (20 products), and *Performance Metric* measuring coating performance on a scale of 0 (best) to 100 (worst).
- **Data Exploration:** For robust analysis, we require sufficient sample sizes, defined as 10 samples, for 20 products across 9 operating routes and 3 activity groups. However, the raw dataset lacks 148 (*Product Code*, *Route Number*, *Activity Group*) combinations and contains 200 combinations with small sample sizes, necessitating subsequent extrapolation.

3. Data Interpolation

Three extrapolation approaches as provided by AkzoNobel (Marie, 2023) to address the missing and small sample combinations:

- **By Activity:** Infer the performance values from positive records of its lower activity levels; for example, when interpolating data of 31-60% activity group, data from the 0-30% group can be used based on matching product code and route number, excluding the 0-30% group.
- **By Time:** Extrapolate performance values of later records from corresponding previous records. For instance, when interpolating 37-60 *Scheme Group* data, estimate the performance value based on the its matching 0-36 *Scheme Group* if available. The inference is obtained by the mean performance difference between paired 2 scheme groups data in the dataset.
- **By Product:** Informed by predefined performance comparison rules in Table 1, for products with equal performance, the *Performance Metric* from available "Product Y" is employed; for products with differing performance, the mean performance difference between comparable products ("Product Y") and the product to be interpolated ("Product X") is used to infer the corresponding performance value

Product X	Comparison	Product Y
Product I (if Product D present)	==	Product D
Product I (if Product D absent)	==	Product B
Product I	<	Product K
Product K	>	Product I
Product N	>	Product A
Product N	>	Product M
Product N	>	Product Q
Product O	==	Product F
Product F	>	Product C
Product F	>	Product H
Product F	>	Product L
Product S	>	Product P
Product S	>	Product G
Product H	==	Product C
Product H	>	Product L
Product C	>	Product L
Product C	==	Product H
Product A	<	Product N
Product A	==	Product M

Table 1. Product Comparison Rules

We will follow the step-by-step order of by activity, time and product for the interpolation.

4. Assessment

The results of Traffic Light system assessment among three activity groups are presented as followed:

- **Quantitative Assessment:** Average *Performance Metric* value for each unique combination (*Product Code Route Number*, *Activity Group*,) are considered as the quantitative evaluation of the performance of this combination, which are presented as the ranking targeted products from the smallest value (best) to the largest (worst) on 9 routes for 3 activity groups.
- **Qualitative assessment:** Traffic Light system will be used to qualitatively assess the performance of each unique combination, where classifying the mean performance value into three "lights", green for high performance, red for poor performance and yellow for the moderate performance.

Ranking	Route 1	2	3	4	5	6	7	8	9
1	I*	N	S*	I*	N*	N*	I*	N	S
2	M	S	I*	S*	S*	S*	O	I*	N*
3	N	O	N*	N*	I*	M*	N	S*	I
4	Q	I	O	M*	A*	Q*	M	M	O
5	S	Q	Q*	Q*	M*	I*	Q	Q	M
6	A	A	M	O	O	G	K*	A	K
7	R	G	K*	R*	Q*	F	S*	O	Q*
8	F	F	G	F	K*	K*	A	K*	G
9	O	K	R*	K*	F	O	G	G	F
10	K	M	A	G	G*	A	F	F	A
11	G	R	F	A	R*	R*	R	R*	R*

0-30% Activity Group

Ranking	Route 1	2	3	4	5	6	7	8	9
1	I	N	N	I	I	I*	I*	I	I
2	M	I	I	K	N	N	N	N	O
3	F	K	K	G	M	M	K*	A	N*
4	A	G	S	A	A	S*	A	F	S
5	K	Q	Q	F	K*	G	G*	S*	K
6	N	F	A	N	O	Q	M	K	G
7	Q	A	G	S	F	K*	O	M	M*
8	S	R	R	M	S	A	Q	O	F
9	G	S	O	R	G	F	S*	G*	A
10	R	O	F	O	Q	R	F	Q	Q*
11	O	M	M	Q	R	O	R*	R*	R*

31-60% Activity Group

Ranking	Route 1	2	3	4	5	6	7	8	9
1	N	I	I	I	I	N	I*	N	I
2	A	N	N	N	N	I*	O	I*	N*
3	I	G	M	S*	A	G	N*	A*	K
4	M	K	S	A	K	S	K*	M*	A*
5	K	M	K	K	S*	M	F	S*	F
6	S	S	G	G*	O	A	A*	F	M*
7	G	A	A	M	M	Q	G*	G*	O
8	F	O	O	Q	F	F	S*	Q	G*
9	Q	R	R	O	Q	R	M*	O	S*
10	O	F	Q	F	G	K	R*	K*	R*
11	R	Q	F	R	R	O	Q*	R*	Q*

61-100% Activity Group

Figure 1. Traffic Light Assessment (The asterisk indicates instances where the results are derived from small sample sizes).

The assessment framework proposes the following:

- Identification of the optimal coating product for particular routes and activity levels.
- Recognition of products prevalent in the green zone, signifying strong overall performance, while products in the red zone should be targeted for enhancement.
- Accommodation of special product preferences and scarcity scenarios.

5. Conclusion

In summary, our study presents a thorough evaluation of AkzoNobel's Fouling Control Product Performance. By utilizing three extrapolation methods—interpolation by activity, time, and product—we expanded our dataset to encompass 21,749 records, ensuring comprehensive coverage for evaluations. Our quantitative analysis computed average performance values, offering quantified insights into the effectiveness of coatings across diverse combinations. Complementing this, a qualitative assessment utilized the Traffic Light System for visual product categorization. Our methodology supports informed recommendations, identifies suitable coating products for enhancing vessel efficiency and emission reduction, and pinpoints areas for improvement. As AkzoNobel progresses in its coating strategies, our findings provide a strategic roadmap for a sustainable future, paving the way for future research to refine assessments and strengthen environmental stewardship.

6. Reference

1. Marie Dale. Product Rule / Activity Rule. AkzoNobel. 2023
2. Pistone A, Scolaro C, Visco A. Mechanical Properties of Protective Coatings against Marine Fouling: A Review. Polymers. 2021; 13(2):173.

Project Github: https://github.com/wenyan512/Fouling-Control-Coatings-Performance-Assessment.git