Surfactant Memorandum

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**Recommendation**

The recommendation of the analysis team is that the company proceeds with the purchase of surfactant from the lot from which come NK-R102 and NK-R104.

**Context**

A biotechnology company needs to evaluate a new raw material for use in its emulsion solution. The emulsion solution is composite of water-based media broth micelles suspended in an oil solution. Each micelle is used for growing and analyzing a bacterial cell with the hopes of diagnosing infections in future patients. By measuring properties of bacterial fluorescence under experimental conditions, the type of bacteria is determinable.

The key part of the oil solution that is responsible for maintaining its micellular formation is called a surfactant. The raw materials used to make the surfactant strongly impact how stable the emulsion will be. If the emulsion is weak, the micelles will collapse into one giant mass and be regarded as useless. In an emulsion of medium quality, some micelles will collapse. In this case, bacterial cells can come together in groups. The intensity of the fluorescence of the groups can interfere with measurements of the fluorescence of single cells.

This company needs to test a new raw material to see if it creates a stable emulsion. If it does indeed create a stable emulsion, then the company will move forward and purchase $30,000 of the new raw material. Four surfactants are relevant to the study, herein referred to as NK-R38, NK-R84, NK-R102, and NK-R104. Variability in the manufacturing process means that the quality of surfactants can vary between manufacturer’s lots and even between bottles. NK-R102 and NK-R104 were individual bottles from the same manufacturer’s lot; NK-R84 and NK-R38 each come from a different lot. NK-R38 has been chosen as the standard; it is of the quality the team wants from the surfactants. The lot from which NK-R38 comes, however, is sold out. NK-R84 is of the minimum quality to proceed. The order in question would come from the same lot as NK-R102 and NK-R104. *The central question of this study is whether NK-R102 and NK-R104 are of sufficient quality to justify such a purchase.* The team examined this question by comparing their performance in terms of four metrics: total droplet count, doublet count, fill factor ratio, and fill factor score, discussed below.

**Experimental design**

The approach to analyzing the stability of the emulsion uses lung samples collected from humans. The heterogeneity of these samples puts sufficient stress on the micelles to reflect what will happen *in vivo*. The goal is to stress the emulsion to a breaking point and analyze the degree of droplet coalescence in comparison to a control.

The surfactants made with the new raw material will be tested against two control surfactants, mentioned above:

-positive control: NK-R38

-negative control: NK-R84

The test surfactants are NK-102 and NK-104.

The metrics used to evaluate surfactant stability are:

* Total droplets (a decrease in this number is a sign that droplets coalesced, resulting in a fewer droplets)
* Doublets formed (measures how many drops coalesced from a singlet—one drop—into a doublet—two or more drops)
* Fill factor ratio, determined by dividing the final fill factor by the initial; fill factor is a normalized measurement of the fullness of the circuit of singlet micelles (when this number moves away from 1, its means there are fewer droplets observed at the end of the trial than were observed in the beginning of the trial, leading us to conclude that they have coalesced)
* Fill factor score, established as the absolute value of the difference between one and the fill factor ratio (A fill factor score of zero, therefore, is perfect. In principle a fill factor ratio greater than one is impossible, since droplets do not coalesce. Due to measurement error, a ratio greater than one is measured in some cases.)

For an ideal surfactant, zero doublets should be present in all samples, fill factor ratio should be equal to 1 in all samples, and each circuit should have 25,000 total droplets in all samples.

NK-R102 and NK-R104 perform better than minimum quality by all measurements. In some cases, they exceed the quality of NK-R38.

***Table 1***

***Highlighting Means***

|  |  |  |  |
| --- | --- | --- | --- |
| **Comparison** | **Metric** | **Group1 mean** | **Group2 mean** |
| NK-R102\_vs\_NK-R84 | doublets | 103.47 | 194.4170854 |
| NK-R102\_vs\_NK-R84 | FFF/FFI | 0.005963316 | 0.009356229 |
| NK-R102\_vs\_NK-R84 | total\_droplets | 22582.865 | 21921.75377 |
| NK-R104\_vs\_NK-R84 | doublets | 89.87437186 | 194.4170854 |
| NK-R104\_vs\_NK-R84 | FFF/FFI | 0.004432771 | 0.009356229 |
| NK-R104\_vs\_NK-R84 | total\_droplets | 22301.13568 | 21921.75377 |

Given the significant improvements in doublets, FFF/FFI, and total droplets metrics, both NK-R102 and NK-R104 demonstrate superior performance over NK-R84. Specifically, NK-R102 and NK-R104 show reduced aggregation (lower doublets), better stability (lower FFF/FFI), and more consistent results (total droplets).

***Table 2***

***Statistical Test Results***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Comparison** | **Metric** | **T-test p-value (log)** | **U test** | **(Cohen's d)** |
| NK-R102\_vs\_NK-R84 | doublets | ***5.55165E-15*** | ***3.20599E-17*** | -0.464341873 |
| NK-R102\_vs\_NK-R84 | FFF/FFI | ***0.036210703*** | ***0.013303927*** | -0.204079682 |
| NK-R102\_vs\_NK-R84 | total\_droplets | ***0.001723826*** | ***3.11238E-16*** | 0.475888728 |
| NK-R104\_vs\_NK-R84 | doublets | ***2.05318E-16*** | ***5.40838E-17*** | -0.615087748 |
| NK-R104\_vs\_NK-R84 | FFF/FFI | ***0.001861186*** | ***8.14803E-05*** | -0.302834786 |
| NK-R104\_vs\_NK-R84 | total\_droplets | ***0.008448278*** | ***8.37538E-07*** | 0.312706318 |

*Note: Everything in green is statistically significant. Choen’s d is a measurement of effect size.*

Therefore, it is recommended to prioritize the use of NK-R102 and NK-R104 over NK-R84 in applications where minimizing aggregation and improving stability and consistency are critical. This choice will likely enhance overall performance and reliability, making NK-R102 and NK-R104 the preferred options in such scenarios