Aqua PUR®: Polyaspartic Elastomeric Coating for Palm Oil Mill Applications

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INTRODUCTION

Urbanisation and industrialisation across the world demand for cutting edge technology. Commercial markets are always in search of one-stop total solutions for common industrial problems and this has brought about inventions that are able to handle multiple issues while being economical and high in quality. Even the global powerhouse nations are always able to rise up with innovations to fill the gaps; Malaysia could also presently join this benchmark with a revolutionary solvent-free polyaspartic elastomeric coating which has undergone international standard testing to ensure its outstanding quality.

Practical experience shows that there is no single product available in the market that has true water permeability resistance to handle waterproofing related issues with high success rate warranty even when utilised properly. Many internationally accredited products that were claimed to be effective in other countries somehow failed to fulfil the expectation when applied in Asian climates. However, a Malaysian organisation undertook the challenge to develop their own polyaspartic elastomeric coating known as Aqua PUR® as shown in *Figure 1*. Aqua PUR® has been proven to perform excellently for waterproofing and in other surface coating applications such as lining, seamless flooring and many others.

Figure 1. Aqua PUR® Polyaspartic elastomeric coating chemical compound.

In a growing health-conscious community, demand for food safety has increased steadily. As a result, almost all edible product manufacturers have pursued to comply with the mandatory Food Hygiene Regulations 2009 (Kim-soon *et al.,* 2017). As one of the elements in the palm oil products supply chain, palm oil mills are currently urged to acquire relevant certification schemes such as *Skim Pensijilan Makanan Selamat Tanggungjawab Industri* (MeSTI) introduced by the Ministry of Health, Malaysia. Seamless flooring such as the one shown in *Figure 2* is an example of a common requirement in all food safety assurance certification schemes including MeSTI (Food

Hygiene Regulations, 2009). It is to prevent contamination due to the growth and spread of bacteria in food handling processes. Practically, for palm oil mills, the mill flooring must able to handle high abrasion and harsh conditions to meet daily operation requirements. This is where a polyaspartic elastomeric coating can play a role in helping the industry meet this standard.

Figure 2. Example of application of seamless flooring using Aqua PUR®.

Palm oil mills generate palm oil mill effluent (POME) at an average of 25 000 ppm biological oxygen demand (BOD). The POME needs to be treated to reduce the BOD level to below a relevant standard requirement set by the Department of Environment Malaysia (Muzzammil *et al.,* 2021). Almost all Malaysian palm oil mills adopt earthen biological treatment ponding system because of the low operating expenditure (OPEX) and capital expenditure (CAPEX) (Mohd Ali Hassan *et al.,* 2006). Earthen treatment ponds promote direct contact between the untreated POME and the soil, thus posing a potential risk of contaminating nearby ground water via seepage in the long run (Suratman, 2010). In addition, the exact sludge levels at the bottom of the ponds are unable to be determined during de-sludging due to the uncertainty of the pond's base level. Thus, most mills estimate the sludge content using primitive methods making a practically complete sludge removal unlikely to occur.

An alternative option by using concrete pond construction as treatment ponds is an expensive as well as labour-intensive endeavour. Furthermore, concrete ponds may develop hairline cracks after merely months of service life due to uncontrollable shear stresses caused by earth movement. Other critical structures in a POME treatment facility are bund walls and slopes. Excessive rainfall during the monsoon season causes effluent levels to rise and bund walls to crack which could lead to environmental contamination. Again, application of concrete and embedded beams to make the soil firm on the slope is an expensive solution.

There is a huge potential to benefit from the application of Aqua PUR® for these important structures in palm oil mills. Lining of the POME treatment pond and its bund wall as well as slopes around the POME treatment facility has become more relevant today for environmental and structural advantages. A demonstration of its application is as shown in *Figures 3* and *4*. Aqua PUR® in such application has the potential to reduce the construction cost drastically and makes the structure long lasting with minimum maintenance costs.

Figure 3. Unlined pond (above) and lined ponds using Aqua PUR® (below).

Before slope protection *After slope protection*

Figure 4. Polyaspartic elastomeric coating slope protection.

PRODUCT TESTING AND ANALYSIS

The formulated preparation of Aqua PUR® has been sent to SIRIM QAS International Sdn. Bhd. for multiple testing to establish a set of parameters conforming to various industrial requirements and applications (*Tables 1* and *2*). The testing was focused on the physical properties of the product. This is to confirm its durability, strength, robustness and other physical features that will make it suitable for harsh and rugged environments. Additionally, a microbiological study (cytotoxicity test) was also included to analyze its effect upon human contact with regards to water quality.

TABLE 1. ANALYSIS TO ESTABLISH PHYSICAL PROPERTIES OF AQUA PUR®

Test	Standard
Tensile strength	ASTM D 412 -13
Elongation at break	ASTM D 412 -13
Tear strength	ASTM D 624-12
Water tightness resistance	BS EN 1928:2000
Water absorption	BS 1881-122:1983
Water vapour transmission rate	ASTM E 96 /E96M-16
Pull-off adhesion	ASTM D 4541:09

TABLE 2. MICROBIOLOGICAL ANALYSIS (CYTOTOXICITY TEST) OF AQUA PUR

Test	Standard
Suitability of non-metallic product for use in contact with water intended for human consumption with regards to their effect on the quality of the water	BS 6920-1: 2014
Suitability of non-metallic materials and products for use in contact with water intended for human consumption with regards to their effect on the quality of the water	BS 6920-2.1:2014
Suitability of non-metallic product for use in contact with water intended for human consumption with regards to their effect on the quality of the water: the extraction of substances that may be of concern to public health	BS 6920-2.5:2000+A2:2014

Results (*Table 3)* showed that Aqua PUR® has high water permeability resistance. Water tightness test indicated that the material is good for waterproofing as no water penetration occurred after the material was subjected to 60 kPA for 24 hr. Furthermore, water absorption test showed there was no absorbed water present in the cement specimen that was coated with Aqua PUR®. Water vapor transmission rate analysis also showed that an extremely low level of water vapour permeated through the material. Aqua PUR® also exhibits good elongation property. With a sample thickness of only 0.68 mm, the elongation at break of the material was measured at 242.1% with tensile force measured as high as 21.3 MPa. This means that the material can be stretched to more than twice of its original length at a very high force. The material also showed high resistance to tearing or shearing forces as it can withstand 192.6 N/mm before it breaks. The material proved to have high adhesive properties where 714 psi was needed to detach the material in the pulled-off adhesion analysis.

A screening procedure (simple cytotoxicity test) to test leachates from the polyaspartic elastomeric coating of a biologically active compound was carried out according to BS6920. Leachates from the sample after a 24 hr extraction at 23 ± 2°C was used to prepare the growth medium. The morphology of a mammalian cell line following a 24 hr culture in the growth medium was observed. Cell cultures in the extract of sample pieces showed healthy confluent monolayer, which indicate a non-cytotoxic response (*Table 4).* Monolayer of cell culture was not present in the validation solution.

CONCLUSION

On the basis of the results from various tests performed on the material, the Aqua PUR® sample showed outstanding features with respect to providing a durable, long lasting, robust and safe coating suitable for harsh and rugged environments. Its excellent waterproofing ability would be beneficial in facilitating the management of POME treatment in palm oil mills with respect to environmental and structural aspects. The material also complied with all the requirements of MS 1583: Part 1: 2003, Clause 7 implying that it is safe to be used in a strict food grade environment. To conclude, the application of Aqua PUR® in palm oil mills is highly recommended especially for pond lining treatment to avoid ground water contamination due to leaching and floor coating for food safety assurance compliance.

TABLE 3. SUMMARY OF PHYSICAL PROPERTIES RESULTS FOR AQUA PUR®

Type of Tests	Test Methods	Results
Tensile Strength Speed : 500mm/min Dumbbell type : Die C Sample thickness : 0.68 mm	ASTM D 412 -13	21.3 MPa
Elongation at Break Speed : 500mm/min Dumbbell type : Die C Sample thickness : 0.68 mm	ASTM D 412 -13	242.1 %
Tear Strength Test specimen : Type C Thickness : 0.58 mm	ASTM D 624-12	111.7 N (192.6 N/mm)
Hydrostatic Water Pressure / Water Tightness Resistance Method A - Water tightness at low pressure	BS EN 1928:2000	No water penetrated through the upper filter paper above the surface of the specimens at the applied water pressure 60 kPa during the total test period of 24 hr.
Water absorbtion Drying in oven: 72 ± 2 hr at 105 ± 5°C Duration of Immersion: 30 ± 0.5 min Dimension: 100 mm x 100 mm x 100 mm	BS 1881-122:1983	Measured absorption: 0% Corrected absorption: 0%
Water Vapor Transmission Rate Temperature: 23 ± 1°C Relative Humidity: 50 ± 2% RH (1). Water vapour transmission rate (2). Water vapour permeance (3). Water vapor permeability	ASTM E 96 / E96M - 16 (Procedure B - Water Method)	(1) = 0.41 g/h.m2 (2) = 2.05 x 10-8 g/Pa.s.m2 (3) = 9.32 x 10-12 g/Pa.s.m2
Pull-Off Adhesion Condition: 26.3°C, 65%RH	ASTM D 4541:09	Pulled-off strength= 714 psi (Average)

TABLE 4. CYTOTOXICITY EFFECTS OF AQUA PUR®

	Replicates	Effects on cell culture
Extract of sample piece 1	A	Healthy confluent monolayer.
	B	Healthy confluent monolayer.
	C	Healthy confluent monolayer.
Extract of sample piece 2	A	Healthy confluent monolayer.
	B	Healthy confluent monolayer.
	C	Healthy confluent monolayer.
Validation solution	A	Cell rounding off and floating. No monolayer.
	B	Cell rounding off and floating. No monolayer.
	C	Cell rounding off and floating. No monolayer.
Blank	A	Healthy confluent monolayer.
	B	Healthy confluent monolayer.
	C	Healthy confluent monolayer.

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