The development of living organisms, such as barnacles and algae, on wet surfaces - a biological phenomenon known as biofouling - has been a major problem for mankind since the first materials were used in the sea. Noteworthy, the growth of these large organisms ("macrofouling") is anticipated by another biological phenomenon known as microfouling, or biofilm. This term refers to the formation of a layer of microorganisms that takes place on any surface in contact with liquids. Such microbial slime represents a problem in all technological and industrial applications using water and other liquids. Biofilm growth starts with the colonization of surfaces by free-floating bacteria, which begin to proliferate as soon as they attach to the material. Then, with time, biofilm grows and becomes mature. At this stage, parts of it can detach, cross-contaminating other parts of the system. Therefore, biofilm is never a localized phenomenon.

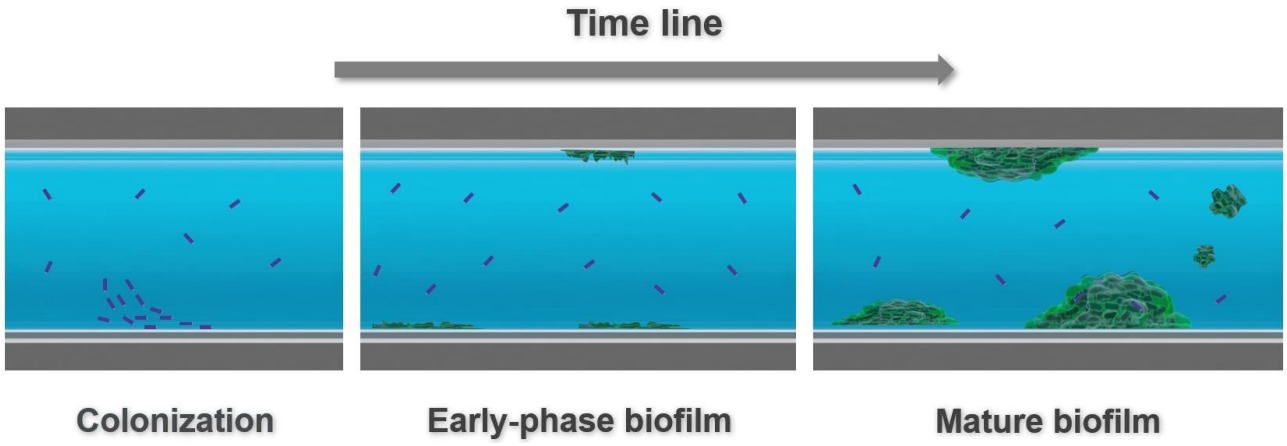

Figure 1: Development of biofilm, from the initial colonization of surfaces to its mature phase

It is also important to note that, since its early phase, biofilm leads to a number of technological issues including corrosion, energy loss, equipment failure and, most importantly, resistance to antimicrobial treatments. Indeed, while free-floating bacteria are easily eliminated by the biocide treatments commonly applied in the Industry, biofilm is more difficult to remove, since it is sheltered by a layer of self-produced exopolymeric substances (EPS). Thus, in order to remove microbial slime, it is important to apply biocide treatments when biofilm is still young - and thus when its protective layer is still thin. If biofilm is allowed to reach its mature phase instead, biocides will only eliminate its outer layer – while bacteria can continue to proliferate in the inner layer. For all of these reasons, biofilm growth should be considered as a key performance indicator of microbial control practices in industrial processes. Nevertheless, the formation of microbial slime on industrial surfaces is, unfortunately, often overlooked.

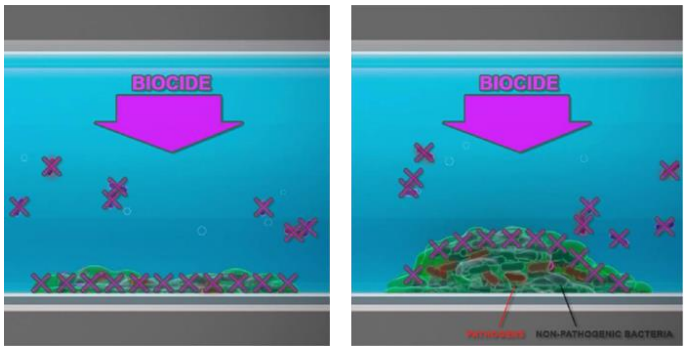

Figure 2: ALVIM Biofilm Sensors

Indeed, the standard approach to microbial control is often focused just on free-floating bacteria – which only represent 10% of the total problem. On the other hand, the majority of bacteria – up to 90% - live in biofilm, which is the main source of microbiological issues. Therefore, technological innovations allowing to shift the focus of microbial control practices on biofilm, rather than free-floating bacteria, can provide a huge added value to cleaning and sanitation protocols.

With the aim to revolutionize the current approach to microbial control, ALVIM developed its innovative Biofilm Monitoring Technologies. Supported by more than 40 years of public and private research, ALVIM Electrochemical Sensors were developed in collaboration with the Italian National Research Council (CNR) and private companies.

ALVIM probes detect biofilm growth online and in real time, providing an early indication of microbiological growth on surfaces in contact with liquids. As a consequence, ALVIM Technology allows to optimize cleaning and sanitation treatments based on real needs. Indeed, thanks to the early-warning signal provided by ALVIM Biofilm Sensors, indicating the very first phase of biofilm growth, it is possible to apply biocide treatments when they are most effective - and also to check the results.

Figure 3: ALVIM Biofilm Sensors

ALVIM Technology is based on a working principle known as cathodic depolarization, or ennoblement, which allows to detect the real bioelectrochemical activity of bacteria. As a consequence, ALVIM probes specifically detect biofilm growth, with high sensitivity. More info about ALVIM Technologies is available at www.alvim.it.

ALVIM Biofilm Sensors are currently employed in a number of Industrial sectors including Cooling Waters, Food & Beverage, Drinking Water, Oil & Gas, Pulp & Paper, Medical & Health. In addition, ALVIM Technologies are already employed by the largest Industrial players in the five continents, with installations in more than 30 countries. Among many other applications, ALVIM Probes were also conveniently exploited in marine environments - for example to extend the lifetime of underwater equipment, prevent microbiological growth on board of ships and safeguard oceanographic sensors.

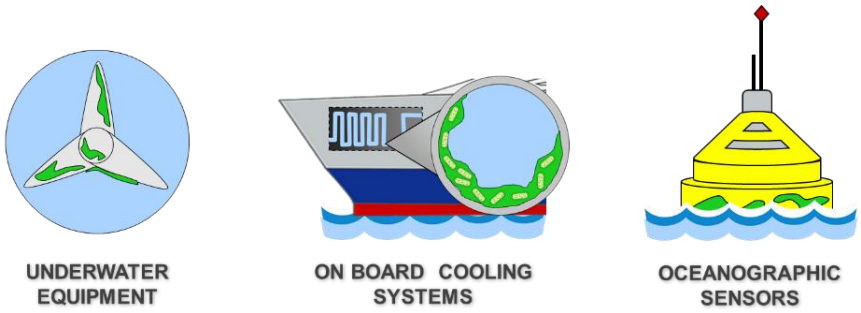

Figure 4: ALVIM applications against Marine Biofouling

With this respect, ALVIM was involved in a number of international projects, developed in collaboration with international partners including Ifremer, Naval Group, the University of Portsmouth and the Massachusetts Institute of Technology.

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