International Journal of Education and Science Research Review
E-ISSN 2348-6457
Volume-9, Issue-5 Sep - Oct – 2022
P-ISSN 2349-1817
www.ijesrr.org
Email- editor@ijesrr.org

A STUDY ON THE PLASMA AND IT'S LIFE CYCLE

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ABSTRACT

Life cycle assessment is used in this article to explore the viability of plasma-assisted procedures for the synthesis of ethylene from rich-in-methane gas streams, namely natural gas and shale gas. These gas streams include natural gas (LCA). Two plasma-assisted process alternatives, a direct gas conversion to ethylene (one-step) and a stepwise gas conversion to acetylene followed by acetylene-to-ethylene hydrogenation (two-step), both of which have been previously demonstrated in the lab and modelled on a large scale, are evaluated using the SimaPro software and ecoinvent database. The one-step process converts gas directly into ethylene, while the two-step process converts acetylene Both of these solutions to the procedure take into consideration a variety of possible outcomes involving the usage of the purge stream and the sources of power. According to the findings of the LCA, it is very likely (with a confidence interval of 93.5%) that the two-step process will result in a less carbon footprint than the one-step procedure would produce. The two-step process, which is powered by energy produced by wind turbines and makes use of the purge stream as a byproduct (rather than flaring it), results in the lowest carbon footprint of all the scenarios that have been investigated. The two-step plasma-assisted ethylene manufacturing method is more ecologically friendly than its peers when natural gas is used as the feedstock. This is because the plasma is generated from water vapour.

Keywords: *Plasma cell, life cycle*

INTRODUCTION

It is essential for the humoral component of the immune system to produce protective antibodies that circulate throughout the body. In human beings, antigen-specific antibodies have been found in the blood serum long after the antigen has been exposed to the organism. Plasma cells, which are stimulated to produce antibodies in response to antigen stimulation, are responsible for the continuous maintenance of the antibody pool.

Because soluble antibodies are required in order to confer protective immunity on a person or animal, these antibodies need to be able to freely circulate throughout the body in order to perform their function as a monitoring system. It is essential that plasma cells be positioned in tissues in such a way that antibody may readily reach the circulation. This is because it is still unknown if plasma cells themselves move from one tissue to another. Plasma cells may be found among the reticular sinusoidal cells in the red pulp and medullary cords of the spleen and lymph nodes, respectively. These areas are rich in the vasculature that is necessary for antibody circulation. However, it is hypothesised that plasma cells interact with the reticular stromal cells surrounding the sinusoidal endothelial cells, again facilitating antibody secretion directly into

the bloodstream. Although the precise location of plasma cells in the bone marrow is unknown, it is known that plasma cells play a role in the production of antibodies. Also see: lymph nodes and the spleen.

Plasma cell morphology

The morphological characteristics that separate plasma cells from mature B cells make it simple to make this distinction. Uncondensed nuclei, a high ratio of nucleus to cytoplasm, and low levels of rough endoplasmic reticulum (RER) are all characteristics of mature B cells. In contrast, plasma cells have a nucleus that is tiny, dense, and eccentric; a substantial volume of cytoplasm that is rich in RER; and an increased number of Golgi bodies (Figure 1).

Development, Differentiation and Migration

Parallels between B-cell development and plasma cell support in the bone marrow

The bone marrow is where researchers find the vast bulk of long-lived plasma cells. Notably, the bone marrow is also the site of significant portions of the early development of B lymphocytes, which are the progenitors of plasma cells. The reticular stromal cell is an essential element in the process of B-cell maturation that takes place in the bone marrow. It makes available

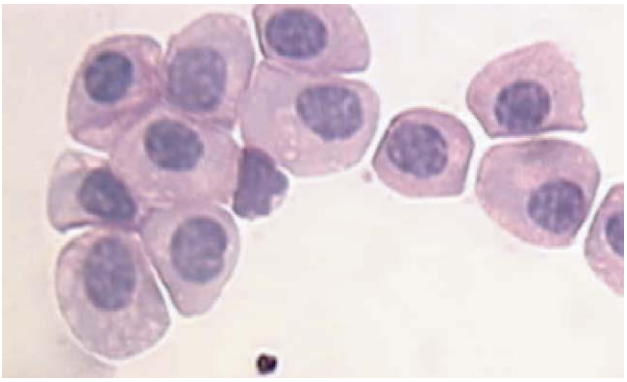

Figure 1 Plasma cells taken from bone marrow and stained with haematoxylin and eosin to illustrate the characteristic appearance of plasma cells

B cells need both the touch and growth factors in order to develop and proceed through their maturation phases. There is a good chance of interaction between plasma cells and growing B cells and the stromal cells that are present in the bone marrow. Because of this, having a significant understanding of the factors that are necessary for B-cell development might potentially shed light on the requirements that are necessary for plasma cell survival. Research has started looking at these kinds of similarities.

There is a lot of overlap between the conditions that must be met in order for B cells to mature and those that must be met in order for plasma cells to survive in the bone marrow. In the first place, it would seem that plasmablasts and plasma cells have re-established their need on stromal cell contact and substances generated from stromal cells in the bone marrow. Similar to what was shown while B cells were growing, contact is essential for the survival of plasma cells: the number of plasma cells rapidly decreases in vitro when stromal cells are not present (Minges Wols et al., 2002). Despite the fact that the growth factors that are necessary for the formation of B cells are not required for the

survival of plasma cells, stromal cell-derived substances are still required. The production of IL-6 by stromal cells, which is essential for the continued existence of plasma cells. Therefore, despite the fact that the actors involved are distinct, the interactive dependencies of plasma cells and B-cell precursors in terms of stromal cells are quite similar to one another in a number of respects (Figure 2).

Plasma cell differentiation

Immature B cells exit the blood and enter the spleen to finish maturing into naïve mature B cells. This process takes place in the spleen. It is possible that, depending on what happens next, some of the naïve B cells may leave the tissue and go back into the circulation in order to continue their search for antigen. Alternately, B cells may come into contact with antigen inside the tissue, at which point the offspring of activated B cells may undergo differentiation into memory B cells, plasma cells, or plasmablasts, all of which will move to the bone marrow. Additionally, refer to B lymphocytes.

Molecular and cellular events of plasma cell differentiation

The shift from the plasma cell state to the committed state is governed by a complex biochemical pathway. One of the most important factors in plasma cell differentiation is a protein known as B lymphocyte-induced maturation protein-1 (Blimp-1), which is a transcriptional repressor. Induction of Blimp-1 expression by cytokine stimulation of the B-cell lymphoma line (BCL-1) Blimp-1 may be found in antibody-secreting cells after either a T-dependent or -independent anti-gen exposure. It can also be found in plasma cells in the bone marrow and in a subpopulation of cells in the germinal centre that demonstrate a T-dependent antigen response.

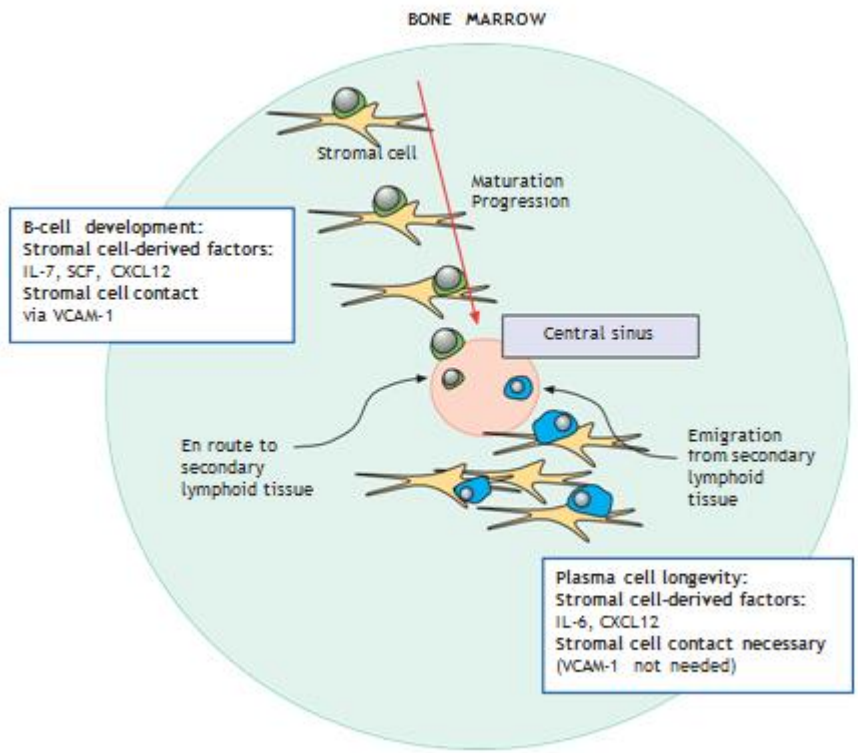

Figure 2 Maturation and migration of developing B cells.

Haematopoietic stem cells may be located in the bone marrow's periphery, and these are the cells that give rise to B cells. The differentiation process moves from the outside edge of the marrow to the centre sinus in a clockwise direction. The production of certain cytokines and the establishment of interaction between stromal cells are both necessary for development. Chemokines, namely CXCL12, are generated predominantly by stromal cells, and these chemokines are responsible for keeping developing B cells in the bone marrow and preventing their early discharge. Developing B cells have CXCR4, the receptor for the cytokine CXCL12, expressed on the surface of their cells. After reaching the stage of immature B cells, the cells stop expressing CXCR4 and are then discharged into the central sinus. From there, they move to secondary lymphoid tissue. Similar to lymphoblasts, plasmablasts that go from secondary lymphoid tissue to the bone marrow seek for stromal cells to sustain their continued existence. Again, stromal cells are responsible for providing the soluble molecules, such as IL-6 and CXCL12, that are required for retention and survival in the marrow. Although contact is essential for plasma cell survival, the adhesion process itself is not well understood. On the other hand, VCAM-1 is not required for the preplasma phenotype. On the other hand, Blimp-1 does not seem to be present in memory B cells (Figure 3).

Plasma cells are responsible for the production and release of antibodies in the immune system. Because of this, the phenotypic of their cell surface is quite different from that of memory B cells. The expression of different cell surface molecules is another way in which the distinct phases of plasma cell growth may be separated from one another. Since plasmablasts are no longer required to bind or present antigen, the expression of the BCR (surface Ig) and MHC Class II are present at decreased levels on the cell surface and are eventually absent from the surface of plasma cells. This is due to the fact that plasmablasts no longer need to do either of these things. Surface expression of the protein B220 is yet another crucial characteristic of B cells. It is not known what role this protein serves; nonetheless, its expression is intermediate on plasmablasts but nonexistent on the surface of plasma cells (Figure 3).

The expression of Syndecan-1 (also known as Cluster of Differentiation antigen CD138) on the plasma cell membrane is the most reliable method for distinguishing plasma cells from other cell types. This antigen is frequently utilised as a method of separation and detection. It has been shown that Syndecan-1 is capable of binding fibronectin, collagen, and basic fibroblast growth factor; however, the effect of Syndecan-1 ligation is not yet understood. Plasma cells, in addition to expressing Syndecan-1 on their surfaces, also show surface expression of the adhesion molecules CD44 and very late antigen-4.

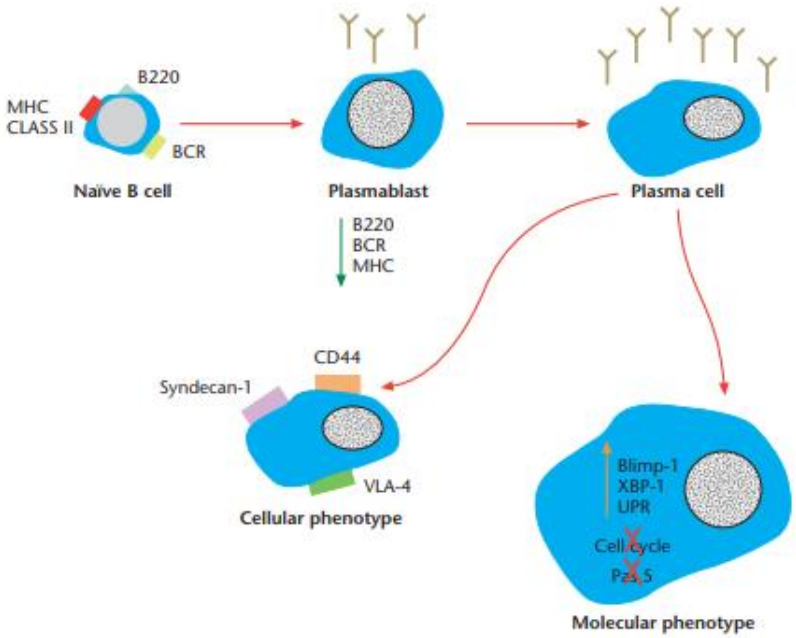

Figure 3 A diagram depicting the progression of plasma cells and the phenotypes they ultimately acquire. When activated with antigen, naive B cells develop into antibody-secreting plasmablasts that are also capable of proliferating. When given the right signals, plasmablasts are able to mature into plasma cells that have completed their differentiation process. In addition to expressing Syndecan-1 (CD138), CD44, and VLA-4 on their surface, plasma cells are able to suppress the production of MHC Class II, B220, and the BCR complex. Plasma cells are found in the immune system. In addition, plasma cells produce Blimp-1 and XBP-1, which ultimately leads to a suppression of proliferation as well as the expression of Pax-5 and a number of other genes (see Figure 4).

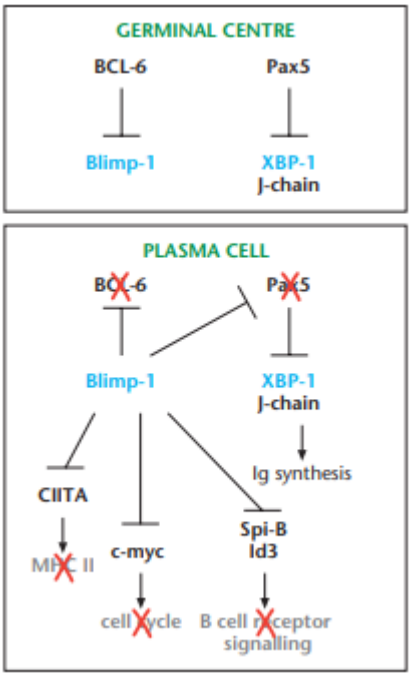

Figure 4 A condensed version of the complex regulatory cascades that are activated during the

differentiation of plasma cells. Targets that have been repressed are shown by bars, whereas targets that have been triggered by a certain factor are represented by arrows.

(VLA-4) (Figure 3) This suggests that there may be many different ways in which plasma cells may make contact with stromal components in the marrow, therefore maintaining the antibody-secreting cells in close proximity to stromal cell-derived survival factors. In addition to this, an increase in overall size may be seen as a result of the forward light scatter that is measured by flow cytometry.

The maturation progression of plasma cells

The phenotypic of the cell surface might vary depending on the organ from which the antibody-secreting human cells were derived. The expression of cell surface molecules shows that maturation progresses from the tonsil to the blood, and then to the bone marrow (Medina et al., 2002). In general, bone marrow plasma cells exhibit the following phenotypes (in comparison to tonsillar plasma cells): the gain of a Syndecan-1 plasma cell phenotype and the loss of a B-cell phenotype (CD19, CD20, CD22, human leukocyte antigen-DR (HLA-DR), and Pax-5, among other things); the gain of the survival factor Bcl-2 and the loss of the death receptor CD95; the gain of adh (Medina et al., 2002). Additionally, antibody-secreting cells from tonsil and blood secrete peak levels of antibody after three days of in vitro culture, whereas bone marrow plasma secretes antibody in a linear fashion for three weeks. This occurs in contrast to antibody-secreting cells from tonsil and blood, which secrete peak levels of antibody after three days (Brieva et al., 1994). These investigations provide insight on the distinctions that exist amongst tissue-tropic plasma cells and imply that the maturation process of antibody-secreting cells progresses from secondary lymphoid tissue to blood, and then on to the marrow as their ultimate destination.

Research carried out on mice provides more evidence that there is a population of precursor plasma cells in the bone marrow. These cells maintain the ability to proliferate and continue to exhibit a wide variety of surface markers associated with B cells, including BCR, MHC Class II, and B220, among others. Due to the fact that these cells still produce antibody, it would suggest that they are not memory B cells. In addition, these cells express VLA-4, CD44, and the IL-6 receptor, all of which are likely to be beneficial to their maturation into terminally differentiated plasma cells in the bone marrow when they are presented with the appropriate stimuli.

Short- and Long-lived Populations of Plasma Cells

In the secondary lymphoid tissue, the antigen that has been processed is delivered to T cells. After the occurrence of contacts between antigen-specific B and T cells, a tight synapse is created between the two cells, which ultimately leads to the activation and proliferation of B cells. At this point, the activated B cells may go one of two ways: either they will differentiate into short-lived plasma cells or they will establish a germinal centre and generate long-lived plasma cells. Both of these outcomes are possible. The majority of long-lived plasma cells are located in the bone marrow, whereas the majority of short-lived plasma cells are found in the secondary lymphoid tissue. This is a generalisation that can be applied to both types of plasma cells. On the other hand, there are still some long-lived plasma cells in the secondary lymphoid tissue.

Generation of short-lived plasma cells

Short-lived plasma cells produce nonmutated IgM or IgG, reach their highest number 8–10 days after an immunisation, and are primarily located at the B/T zone borders of the red pulp in the spleen or in the medullary cords of the lymph nodes. These cells have a shorter lifespan than longer-lived plasma cells. During an initial immune response, the early line of defence against an immunogen is a low-affinity antibody that is released by plasma cells. At the same time, B cells with a higher affinity antibody are being created. The cellular response that occurs in reaction to a secondary antigen challenge is several orders of magnitude larger than the response that occurs in response to a primary vaccination. The population of plasma cells, which have a relatively limited lifespan, makes a significant contribution to the secondary antigen response. According to some studies, the antigen-binding B cells that are found in the marginal zone of the spleen are the precursors of the short-lived plasma cells that are produced during a secondary immune response. These antigen-binding B cells are B cells that have already undergone affinity maturation and selection in the germinal centre during the primary immune response (McHeyzer- Williams, 1997). After receiving a secondary vaccination, the protective antibody that is produced by plasma cells that have a limited lifespan has a higher affinity for the antigen.

Evidence to support the extended longevity of bone marrow plasma cells

The bone marrow develops into a significant location for the production of antibodies. It has recently come to light that the population of plasma cells that is found in the bone marrow is capable of surviving for a very long time. A research conducted on mice found evidence to support this concept by demonstrating that antigen-specific bone marrow plasma cells may persist more than 90 days after vaccination without undergoing cell division. This finding revealed that bone marrow plasma cells are not a dynamic population that is constantly proliferating but are, rather, long-lived cells that produce antibodies in a constitutive manner. There is also continued detection of antigen-specific bone marrow plasma cells for more than 300 days following viral infection (Slifka et al., 1998). Plasma cells that have been transferred to naive mice have been shown to maintain serum antibody levels for more than 120 days after the transfer. This finding lends credence to the hypothesis that plasma cells that have been elicited by a single antigen have a long lifespan and are not a constantly replenishing population. Immunization of naïve recipients with the original immunogen does not change the rates of antibody release from the transferred plasma cells, nor is it essential to sustain the lifetime of plasma cells (Manz et al., 1998). However, there are some people who disagree with this assessment of how long plasma cells live. According to the findings obtained by Ochsenbein et al., (2000), regular antigen exposure is required to keep up a level of antibody protection that is long-lasting.

Cytokine Production by Plasma Cells

The majority of research on the synthesis of cytokines by antibody-secreting cells has been conducted on the cancerous variety of plasma cells known as multiple myeloma cells. Because there is such a large body of research on the subject of multiple myeloma cells, it will not be covered here (although interested parties should review Jelinek, 1999 in the Fur- ther Reading). Unfortunately, very little is known about the generation of cytokines by plasma cells. This is probably due to the fact that it is

difficult to get pure populations in sufficient numbers to carry out tests of this kind. In addition, plasma cells are producing high quantities of Ig and may not use a significant amount of energy in the process of secreting cytokines since these cytokines are easily accessible to them in the milieu that surrounds them. On the other hand, if plasma cells do release cytokines, then IL-6 is a plausible option. This is because IL-6 is required for life, and it is known that myeloma cells produce it through autocrine signalling. According to research, nonmalignant mouse plasma cells did not have any mRNA for the cytokine IL-6; this suggests that IL-6 is not generated by plasma cells themselves (Minges Wols et al., 2002). Therefore, despite the fact that IL-6 is an essential component in ensuring the continued existence of plasma cells, noncancerous plasma cells do not manufacture their own IL-6 but rather stimulate the creation of IL-6 in the cells in the immediate microenvironment. It is obvious that this is a region of plasma cell study that has not yet been studied by researchers, and further information is required in order to have a complete understanding of the complexities of a plasma cell. Additionally, please refer to: cancers of the immune system.

CONCLUSION

Life cycle assessment (LCA) is used to evaluate the viability of two plasma-assisted processes suited for converting rich-in-methane gas streams to ethylene. These processes are considered suitable since they are suitable for the conversion (one-step process: direct gas conversion to ethylene at elevated pressures, and two-step process: gas conversion to acetylene followed by catalytic acetylene hydrogenation to ethylene at atmospheric pressure). The carbon footprint of two possible plasma-assisted process options is calculated, taking into account various purge stream valorization and energy source configurations. According to the findings of the LCA and the uncertainty analysis, it is very likely (with a confidence interval of 93.5%) that the carbon footprint of the two-step process will be less than that of the one-step method for any of the six possible outcomes. When solar panels and wind turbines are used to generate power instead of the grid, the result is a carbon footprint that is nearly four times less than what it would be otherwise.

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