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Mini Review

Porous Titanium Composite Plates for Electrolyzers - A Contribution to Faster Acceptance of Lower-Cost Electrolyzers

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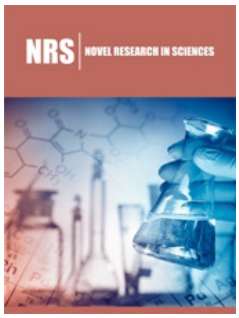

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Mini-Review

An almost abrupt change in attitude towards applications in the field of renewable energies has emerged in recent months, both among decision-makers in politics and in companies [1]. In particular, the topic of hydrogen production by electrolysis plays an eminently important role. In water electrolysis, water is split into its constituent ¬parts hydrogen and oxygen using electrical energy. The resulting hydrogen is of interest to future energy systems for a number of reasons, including the fact that hydrogen can serve as a storage medium for electrical energy from renewable energy conversion systems such as photovoltaic or wind turbines [2]. Polymer electrolyte membrane water electrolysis is considered particularly suitable for this type of application. In polymer electrolyte membrane water electrolysis, the water to be split is fed via so-called porous transport layers to the catalyst layer where the water splitting takes place. These porous transport layers must ensure the outward transport of the water, the outward transport of the produced gas, and the electrical contacting of the electrode [2]. While a few years ago the topic of liquid metal injection molding made a furor and became established in some industrial sectors, the technologies presented here to produce composite materials from metallic powders has been able to establish itself in the energy storage media, i.e., especially in hydrogen production [3]. The key idea here is that conventional polymers are combined with the powders. For example, titanium powder is shown in (Figure 1). Metal composite sheets can be produced in a continuous process. The tool geometry plays an important role in the extrusion process. The plastic melt provided by the extruder flows through the flow channels inside the die and is reshaped towards the outlet cross-section. It turns out that the flow processes in the extrusion die have a significant influence on the quality of the end product. The dimensioning of the flow channel geometry depends on a variety of requirements and shows a significant dependence on the specific rheological properties of the plastic melt, especially when highly filled materials are involved [3].

The next step is the extrusion process with the die shown in (Figure 2). Here it is important that the temperature control is very homogeneous. This should also be investigated in advance. After the extrusion process, the melt has to be cooled down and, if necessary, smoothed [4]. Continuous production of the plates is possible. The decisive factor is that the parameters can be set in such a way that porous plates can also be produced, which can then be used as Porous Transport Layers (PTL). It is important that an exact quantification of the permeation takes place accordingly, therefore the measuring method is explained in more detail, see also (Figure 2). The plates are inserted between 2 glass plates in a U-shaped seal made of silicone and are subjected to vacuum from one side. The other side is connected to the atmosphere. After reaching the specified negative pressure, the vacuum side is hermetically sealed. The subsequent change in pressure within a fixed time window is a measure of the permeation through the test specimen. The measurements were carried out with the

permeation measuring and testing system developed by Eisenhuth. The procedure is as follows: First, the referencing is carried out. For referencing, a geometrically identical dense acrylic disc with the same seal is used.

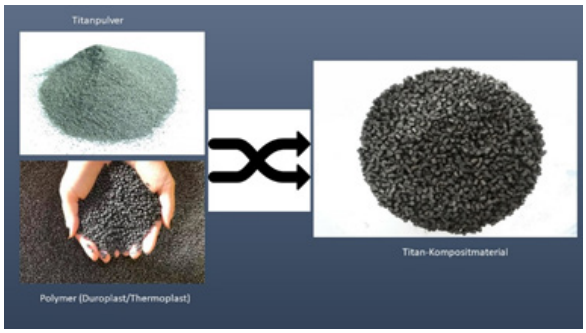

Figure 1: Mixture of polymers and titanium powder to titanium composite material.

Figure 2: U-shaped ring seal together with a test specimen on the measuring device.

Calibration: The calibration refers to the determination of the dead space, i.e., the volume that results from the measuring hoses between the sample, pump, valves up to the transmitter (pressure ¬measurement). The dead space was determined with 15ml.

Calculation: The following algorithm is used to calculate the permeation:

Qv=3600*Delta p*Vtot/(Delta t*pu)

Here the values are:

Qv	ml/h	Permeation
delta p	mbar	Pressure change during the measuring time
Vtot	ml	dead volume=measuring volume
pu	mbar	Ambient pressure

The test procedure in the test device developed by Eisenhuth is as follows:

Phase 1: After inserting the test specimen into the seal and after closing the test device, the vacuum pump is switched on and switched off at approx. 800mbar negative pressure.

Phase 2: Then the system check takes place for approx. 4s together with the test object, without throttle distance to the outside.

Phase 3: Throttle path to the outside with test specimen.

Phase 4: Hermetic sealing of the measuring device.

Phase 5: Relaxation time for seal, test item is active.

Phase 6: Start of measurement=>start pressure, time window starts.

Phase 7: Measuring time.

Phase 8: End of measurement.

The permeation quantity is calculated per time period. The test specimen in the seal lies tightly on the glass plate. A laterally air-permeable felt plate is located on the test specimen. An upper plate, acting as a plane weight force, presses the felt plate onto the test specimen. Thus 2 test areas are created: On the one hand, there is a measuring field under the test specimen as vacuum and measuring space, on the other hand, there is the space with ambient pressure above the test specimen. Permeation through the test specimen therefore takes place from top to bottom. The pressure ¬measured over time in the vacuum chamber is reflected in the permeation flow. The ¬dead space is of decisive importance here. The smaller the dead space, the steeper the pressure curve and vice versa. From the (Figure 3) it can be seen that the pressure is maintained at about 500mbar after the start of the test procedure (after 10 seconds). Constant pressure means: plate is tight. In the following, it is shown for a permeable plate which can be used as a Porous Transport Layer. (Figure 4) shows that the pressure is not maintained after starting the test procedure (after 10 seconds). Falling pressure means: plate is slightly permeable. (Figure 5) shows that the pressure is not maintained after starting the test procedure (after 10 seconds). A strongly decreasing pressure can be observed. This means that the plate is highly permeable and suitable as a porous transport layer.

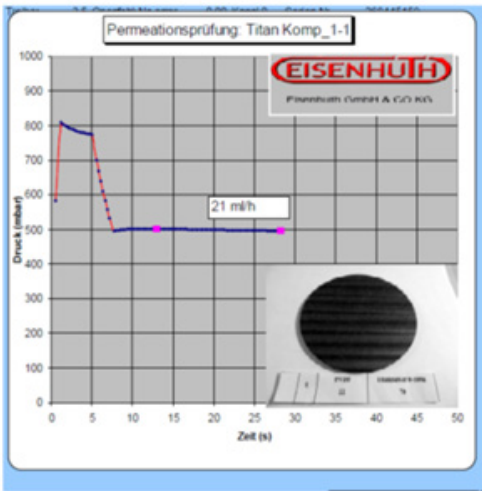

Figure 3: Titanium composite plate: The curve from approx. 10 seconds is horizontal.

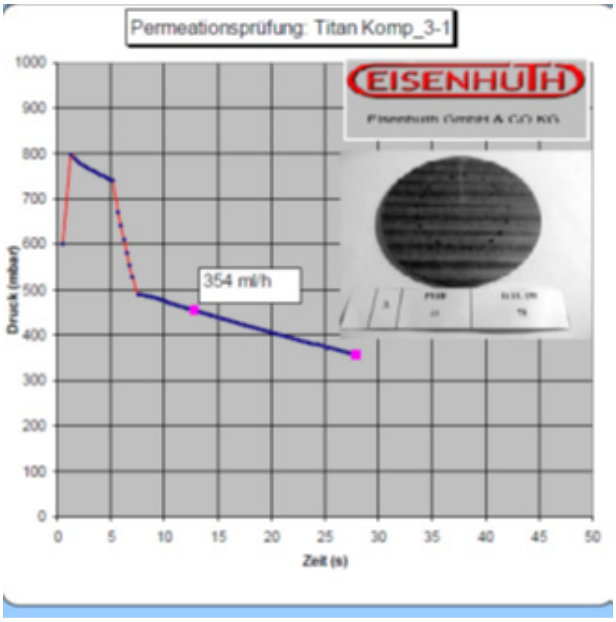

Figure 4: Titanium composite plate: The curve from approx. 10 seconds onwards drops very slightly.

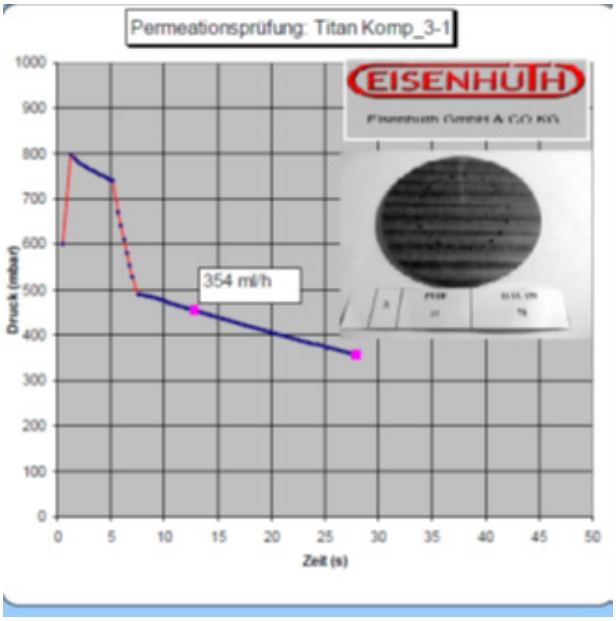

Figure 5: Titanium composite plate: The curve from approx. 10 seconds onwards drops very slightly.

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