SPECIFICATIONS FOR TEST MODULES IN THE APVV PROJECT PP-20-COVID-0002 AEROSOL

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Abstract. The global pandemic of COVID-19 has forced the international community to look for relevant solutions to eliminate the negative effects and reduce the risks of contamination of people with this virus. The research team of the Technical University in Košice, with the support of experts and an application guarantor, BovaCHEM, approached the search for a partial solution within the applied research of a new chemical for decontamination and disinfection of surfaces that may be a source of COVID-19 threat to humans when handling packaging in different conditions. The article presents a partial result of the analytical work within the project, identification and description of specifications for the creation of test modules in the project, for the subsequent verification of the pilot version of the new chemical and its further research to achieve the main goal of the project. The output of the content analysis of the issue, the examination of the patent solution at present, is the synthesis of knowledge, which is reflected in the proposed specifications for test modules and thus for further scientific work according to the approved project APVV until the end of 2021.

Keywords: COVID-19, contamination, personal protection, chemical, test modules

1. INTRODUCTION

The project team decided to respond to the global pandemic of the COVID-19 virus, by identifying a research problem that has several components: health, safety, technology. Following a call from the Science and Research Agency, a research project was submitted on a technological component on: Applied research and development of a working substance for decontamination, disinfection and deactivation, applied to cold plasma at atmospheric pressure, for transport services [1]. The project solution period is 2020-2021. The object of the research is a partial aspect of human exposure to the COVID-19 virus. We are looking for answers to the question, what will we examine? The subject of the research is that part of the research object on which the scientific-research and cognitive activity of the research team focuses, is a new chemical working substance for decontamination, disinfection and deactivation of various surfaces from COVID-19 virus. We are researching a specific aspect of the research object that interests us in the set time 2020-2021.

2. METHODOLOGY OF SOLVING RESEARCH PROBLEM

The research team respects the usual practice of scientific work and the experience that on the basis of the study of literature, personal interviews, observation, study of the results of previous research, we specify our research topic and conceptually shape the situation into a problem. One and the same object of knowledge can become the subject of research in different sciences. In our project, the subject of research is solved within the technical and natural sciences. In accordance with the project schedule, the research and cognitive activities of the research team focused on content analysis of the issue, research of the patent solution at present, synthesis of knowledge and description of partial solutions, which are reflected in the proposed specifications for test modules and further scientific work according to the approved APVV project by the end of 2021.

The current state of results in the project is represented by a pilot version of a new chemical substance (version 1). To continue the project and further analysis of the chemical, we need to produce test modules that will be part of a comprehensive technical equipment. Our strategic intention is to design a technical device using cold plasma technology, into which we will inject a new chemical substance for better decontamination, disinfection and deactivation of material surfaces, applied to cold plasma at atmospheric pressure. These test modules are needed for our planned experiments and to ensure the reliability and validity of the research tools.

3. PARTIAL RESULTS OF RESEARCH PROJECT

At present, it is possible to get to know and analyze the various experiences in the fight against COVID-19, in various studies, documents of international organizations and important research teams.

3.1. Content analysis and study of experience

As part of the historical content analysis of experiences and case studies, our research team studied issues such as:

- from the SARS period - severe acute respiratory syndrome [2];
- the conclusions are confirmed, for example, by a recent study on the impact of a selected airport network on the spread of the virus [3];
- modern documents and regulations of the International Civil Aviation Organization (COVID-19 aviation recovery task force established by ICAO, International Airport Review, 30 April 2020 [4]);
- knowledge of major international airports, such as Heathrow COVID-19 detection trials. Heathrow Airport Limited, 06 May 2020 [5];
- Cerri R.: COVID-19: Using technology in airports to fight a pandemic. ACI Insights. 22 April 2020 [6];
- aviation operations during COVID-19 business restart and recovery [7];
- conceptually interesting and close to our project is, for example, the industrial product of Relyon plasma GmbH, Regensburg, Germany: plasmatool [8] (see Fig. 1);

Figure 1 Plasma tool for generating a plasma beam.
Source: https://www.relyon-plasma.com/relyon-plasma-products/plasmatool/?lang=en

- An important source of knowledge for our analytical work was the patent: We have identified a similar European patent for the planned solution of the problem within the project: EP2016809B1 COLD PLASMA HANDSET FOR PLASMA TREATMENT OF SURFACES [9] (see Fig. 2);
- impact on airport industry, as in [11];
- mathematical modelling and spreading of virus, as in [12];

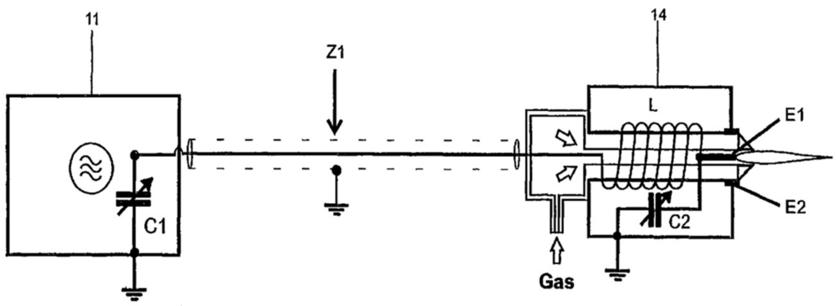

Figure 2 Plasma tool for generating a plasma beam
11 high frequency generator, C1 and C2 capacitors, Z1 filling pipe, Inductance L, E1 and E2 electrodes, GAS
Source: patent application EP2016809B1/DE102006019664

3.2. Design and description of specifications for test modules in the APVV project

Based on the analysis and study of previous knowledge, the first publications [10], the research team created a concept of test modules for future technical equipment using cold plasma technology, into which we will inject a new chemical for better decontamination, disinfection and deactivation of material surfaces applied to cold plasma at atmospheric pressure.

Based on empirical experience and the innovative intention of the project, we have set the following specifications for their production:

Part: High voltage source for cold plasma generator based on the dielectric barrier discharge principle.

The source will be used for both variant A and variant B of the test module.

- The power supply must have variable end user parameters at the output in the range of at least: 6-16kV, 12-30kHz and must provide power in the adjustable range of at least 700W
- Power supply 230V AC mains
- HV outputs for test modules must be equipped with wires (1.5 m) with contacts for mounting on the electrodes of the modules, including the required ground (3 m)
- Equipping with HV probe and current probe for measuring the supplied HV voltage, current and frequency using an external measuring instrument with electronic oscilloscope UT-81C (provided by the client) or using an analog oscilloscope TESLA
- Approximate set values of output voltage, current and frequency on the source must be displayed digitally or analog
- HV conductors with a length of at least 1.5 m must be equipped with removable connections to the electrodes of the test modules
- The ground wire of the MV power supply of the test module must be at least 3 m long
- The design of the power supply must ensure maximum safety of the operator and must be equipped with elements capable of responding to system overload, with the possibility of returning to the original operating mode.

Part: Common elements to support the work of test modules
Systems for the distribution of gases and liquids to the test modules will be set u of the following elements:

- Silicone hose 8 / 10mm (part 1 / item 12)
- Compressor pump HSENG AS-20 (part 1 / item 9)
- Compressor FENGDA AS-06 (1/9)
- Float flow meter AIR 0-60L / min, 1 / 8-8 / 10 (1/14)
- Float flow meter Ar / He 0-5L / min, 1 / 8-8 / 10 (1/14)
- Vacu-Guard air filter, connection 6-10mm (1/12)
- Pressure reducing valve N2-Ar (1/14)
- Throttle valve RFO383-1 / 8 (1/14)
- T-shape S2060-1 / 8-1 / 8
- Direct screwing 1510-10 / 8-1 / 8
- Grommet 1510- 10 / 8-1 / 8-1 / 8- 10/8
- Direct screwing 1463-10 / 8-1 / 8
- Reduction 6 / 8-4 / 6
- Isocratic pump KAPPA Pump 0,1-10ml / min (part 2 / item 3)
- In-line restrictor (2/3)
- SS tubing 1 / 16-0,1 (2/3)
- PEEK tubing 1 / 16-0,1 (2/3)
- Coupling PEEK-SS tubings
- Fitting with ferrule
- Technical gases N2 / 2x10L / 30bar and Ar / 2x10L / 20bar.

Part: Experimental source for piezoelectric plasma generator
It will be used to power the piezoelectric crystal for both variant A and variant B of the test module.

- controlled power supply powered by DC must have an output characteristic in at least the range: 5-15V, 5-10W, 70-90 kHz, with optimum 7V / 5W / 82kHz / input capacitance 0.75uF
- a current and voltage probe with wires is required, enabling the analysis of the output frequency, voltage and current using an external UT-81C
- conductors for powering the piezoelectric cold plasma generator are required with a length of at least 1.5 m, equipped with connections
- supplied external power supply separate DC / AC- laboratory power supply, output values adjustable at least in the range 0-30V AC / 0-40V DC / output current min.6A / display of selected output parameters, mains supply 230V AC
- wires for DC power supply of the generator 7V / 5W / 82kHz must have a length of at least 50cm.

Test module A
Complete assembly of the entire module is required. Items SS tube 1 / 16-0,1, Fitting with ferrule, quartz tube 150mm / ID 2,5mm / OD 5mm will be delivered. Assembled piezoelectric crystal in a plastic case. Direct screwing 1 / 8-10 / 8. Quartz tube 200mm / ID 5.5mm / OD 10mm, 23. UVC-lamp. The assembly must ensure the mechanical cohesion and tightness of the parts while maintaining the required parameters. All assembled parts must be releasable by the user without risk of loss of critical properties:
Part 1 Piezoelectric generator
The piezoelectric crystal will be delivered by the client already in the form of a plastic cylinder with integrated piezoelectric crystal. The same solution will be used for testing module B.

- Manufacture of plastic sheet or polymethyl methacrylate (PMMA) parts. To procure PPMA transparent blocks 20x80x80mm,
- Part No. 9 is equipped for connection to the aerosol part 1 by means of a 10 mm internal thread. The other side contains a groove for silicone sealing of a tube with a piezoelectric crystal,
- Part 12. Includes a groove for silicone seal and on the other side a thread for direct screwing 1/8-inch-8 / 10mm hose,
- Insert the piezoelectric crystal in the housing between parts 9 and 12. Connect parts 9-12 with corner holes using 4x threaded rod with M 4mm nuts fitted on both sides. The connection of the part 11 to the two plates 9 and 12 must be gas-tight,
- Assembly of part 0- Piezoelectric generator. This assembled part will no longer be disassembled during the experiment,
- The assembled part must be tested for connection to the test module.

Part 2 contains the 2nd stage of ionization of the working substance in the aerosol. The OD 5mm quartz tube of part 1 is inserted into the OD 10 / ID 5.5mm quartz tube in part 2. The tubes are secured against disconnection by a union nut with a seal mounted on a holder, which is screwed onto the carrier. Parts 17, 18 must be made of polypropylene or nylon. On the holder and place the rod for mounting on the laboratory stand.

- The carrier represents an open U-shape through which a quartz tube OD 10mm passes freely. The bottom cover, which is removably mounted on the U-shape, is adapted for the installation of a complete UVC source 230V AC with a power cable routed through the open side of the U-shape. The upper removable lid, together with the element, is adapted for the insertion of a radioisotope source or blinded with a screw. All parts are made of plastic - PP or nylon, or light alloy.

Test module B

It comprises a piezoelectric crystal matching part 0 and a UVC-RN aerosol ionization matching part 2 as test module A. These parts do not need to be manufactured, but must be tested for the ability to form test module B.

- Part 3A. Part made of polypropylene or nylon plastic or steel. The part is adapted on one side for mounting a fitting with a ferrule through which the PEEK tube 1/16 passes up to the body of the part. The connection must be airtight. The part is terminated by a capillary, which is end-equipped with a ball to improve aerosol formation.
- Part 3B. Part 3A is screwed into part 3B to form a gas-tight connection. The quartz tube ID 7mm / OD 10mm is slid on the other side of the part. From the side, the tube is equipped with a 10 mm thread for fixing part 0 with a piezoelectric generator supplying ionized air. This bypasses the inserted capillary 3A in the tube 3B and opens into the quartz capillary ID7 / OD10, secured against sliding out by the cap nut 3C. From the side there is a mounting for fixing the rod for vertical installation on a laboratory stand. All parts are required to be made of polypropylene or nylon.
- Slide the U-carrier of the aerosol ionisation part 2 onto the quartz tube (identical to test module A)
- A working electrode 19 made of pure copper is placed on the quartz tube. The electrode with a 4mm eye must be equipped with a mounting for a MV conductor. The electrode must rest on the surface of the displaceable quartz tube. The fixing of the position is ensured by a plastic screw with a wing head.
- The end of the quartz tube is equipped with a steel reference electrode inserted in the quartz tube. The electrode is equipped with a 4mm eye for the installation of the HV conductor. Delivery of parts for fixing the conductor is required. The electrode is secured against slipping out of the quartz tube by means of a coupling and a cap nut.

Test chamber

It consists of PMMA transparent plates forming a gas-tight tub and of a lid which is gas-tight, removably connected by means of circumferential screws with a nut. The removable lid will contain adapters in the middle for the insertion of the plasma-producing end pipes from test modules A and B, as well as from their separate parts. The lid on the sides will contain straight screws 1 / 8-10 / 8.

The sidewalls will include copper and graphite sliding electrodes on opposite sides, or a copper-copper electrode combination. Electrodes are required to be supplied, including the installation of wires on them. The delivery must include electronics and connections, allowing to analyze the conductivity of the plasma, or the electromotive voltage excited by the plasma, using the UT-81C. The opposite walls will contain a gas-tight closure for the 3mm optical cable of the OES emission spectrometer and a 12mm hole for the installation of a PIR temperature sensor with mounting using a M 12mm circumferential screw with a cap nut. Above the bottom of the chamber there will be a direct screw for the removal of gases from the chamber 1 / 8-10 / 8 hose. At the bottom in the middle of the chamber, it is required to place a stand allowing the height of the sample to be adjusted.

The sample area must be protected by a glass plate.

Safety chamber

It will be made with transparent 3 mm PMMA boards glued with a gas-tight joint.

The FVJ-90 filtration and ventilation unit will be integrated in the ceiling, which will be supplied to the equipment manufacturer by the client. Parts for FVJ assembly are required to be made of plastic or Al-alloy according to diagram 10 / FVJ adapter No. 1 and 1A. A replaceable MOF filter with a standard thread Rd40mm-1 / 7inch according to EN143 will be installed in the mounting part at the air inlet from inside the chamber. The outgoing air with FVJ will be returned to the chamber by scratching hoses through the side walls, using the flange diagram 10 / item no.2. It is desired to place a rack rod in the center of the chamber to secure the test module. The front door of the chamber must slide upwards, locked in each selected position with a plastic pressure screw. The bottom of the chamber and the upper part will be equipped with 10/8 hose-1 / 8-1 / 8-10 / 8 hose bushings. Auxiliary parts of the chamber are formed by reduction A and carrier B.

2D and 3D drawings are not intentionally mentioned in the article, due to the filing of a utility model application. Technical solutions will be published additionally within the complex technical equipment.

4. CONCLUSION

The output of the content analysis of the issue, research of the patent solution at present, is the synthesis of knowledge, which finds reflection in the proposed test modules, in the description of their specifications and thus for further scientific work according to the approved project APVV until the end of 2021.

Our strategic intention is to design a technical device using cold plasma technology, into which we will inject a new chemical substance for better decontamination, disinfection and deactivation of material surfaces, applied to cold plasma at atmospheric pressure. These test modules are needed for our planned experiments and to ensure the reliability and validity of the research tools. The outputs of the project are directed primarily in their application in air transport but will also find application in other sectors of the economy.

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