Investigation of the properties of textile electrodes in order to apply them as capacitive electrodes

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Abstract – **The paper presents a study of the change in the parameters of textile electrodes depending on the service life and external, mechanical and chemical effects. The aim of the study is to prove their applicability as capacitive sensors for capturing biomedical signals, in terms of keeping their parameters within acceptable limits for repeated use and after long service life.**

Keywords – **capacitive sensors, wearable sensors, biomedical signals.**

I. INTRODUCTION

Today the share of applications for monitoring of certain vital signs directly related to health and quality of life, based on built-in sensors in clothing, interior or in specialized, wearable devices (belts, watches, bracelets) globally is growing.[1-3] Various vital parameters are monitored - temperature, respiration, ECG, oxygen blood saturation, and others. Many of these parameters can be taken with the help of capacitive sensors [4-6].

The advantages of wearing such sensors are both the increased comfort when wearing them and the independence of the signal quality from the galvanic contact of the sensor with the body, due to the lack of such.

One of the possible solutions for wearable electrodes is the use of textile ones. Their main advantages are the relatively low price, the possibility for easy incorporation in the clothing and the real zero discomfort for the patient [7-9].

The present paper presents a study of the possible change in the quality of textile electrodes and in particular - the change in the capacity measured with them, due to their prolonged operation (number of washing cycles), and the strength of the pressure applied to them.

II. METHOD

For the purposes of the work, an experimental setup was created, shown in Fig.1. Electrochemical copper on a fiberglass base (non-etched PCB) was used as the ground electrode. The textile electrode is pressed against the insulation between it and the ground electrode by means of a vertically movable structure of insulating material on which weights of different mass are placed. To measure the capacitance between the two electrodes, a laboratory LCR-meter HAMEG HM 8018 was used, and the measurement for each electrode was made at three different frequencies - 1KHz, 10KHz, 25KHz.

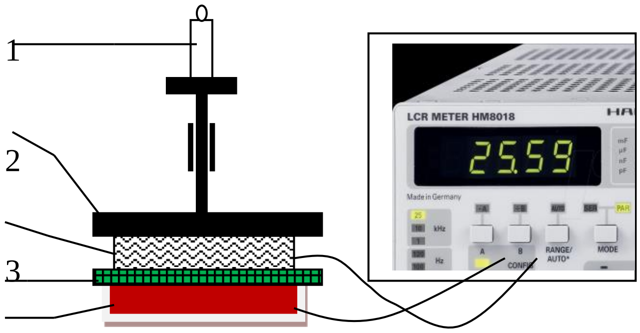

Fig.1 Experimental staging

1 - weight, 2 - movable stand made of non-conductive material, 3 - textile electrode, 4 - insulating layer, 5 - copper (Cu)

III. RESULTS AND DISCUSSION

The capacity of two different types of round electrodes with the same diameter Fig2 (with and without edging) was measured -, at two different loads, respectively with a weight of 0.5kg and 1kg results are shown in Table 1 and Table 2. Some of the electrodes were subjected to a number of cycles (10 and 50 cycles) washed in an automatic washing machine, and another part was soaked with a concentrated NaCl solution and allowed to dry in order to check how the mechanical impact of the laundry on the electrode, and its treatment with various types of chemicals - washing powders and sodium chloride.

Fig.2 Textile electrodes

The measurements were performed in laboratory conditions at room temperature.

At higher applied pressure with the help of the greater weight (1kg), it is logical to find an increase in the measured capacity of the samples of textile sensors, due to an increase in the electrode area due to flattening of the textile threads and filling the distances between them.

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TABLE 1 CHARACTERISTICS OF ELECTRODES WITH OR WITHOUT EDGING AT A WEIGHT OF 500 GRAMS

Capacity pF / Frequency kHz	New					10 washing cycles	50 washing cycles	treated with NaCl
	P 1	P 2	P 3	P 4	P 5	10 P 500	50 P 500	NaCl P 500
1 kHz	42	41	40	100	58	33	21	38
10 kHz	40	40	38	93	57	33	20	32
25 kHz	40	40	37	91	57	32	19	31
with edging weighing 500gr								
1 kHz	274	259	261	257	220	215	96	232
10 kHz	250	237	239	236	204	194	80	213
25 kHz	243	232	234	231	200	189	76	208
without edging with a weight of 500gr								

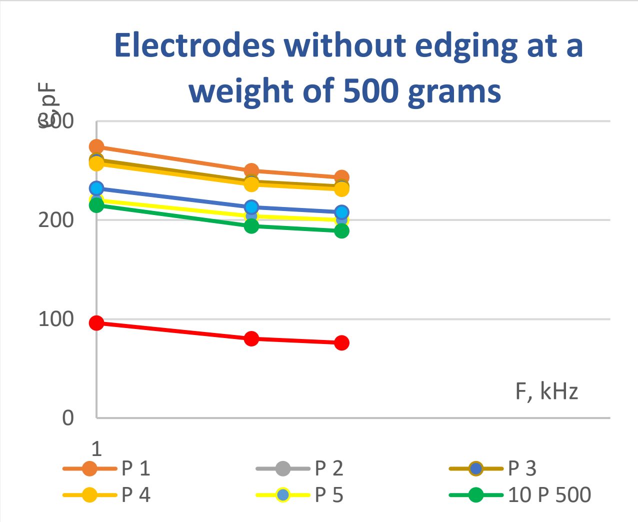

Fig.3: Electrodes without edging at a weight of 500 grams

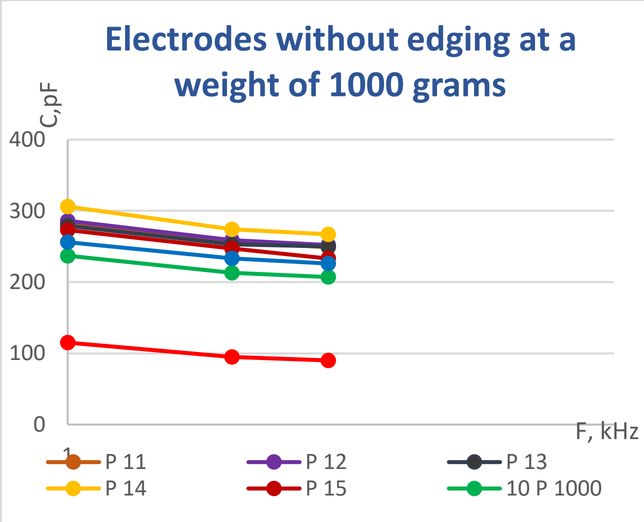

Fig.5: Electrodes without edging at a weight of 1000 grams

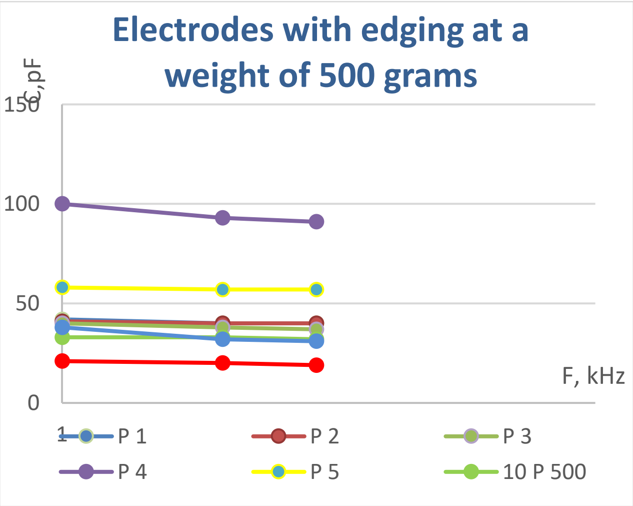

Fig.4: Electrodes with edging at a weight of 500 grams

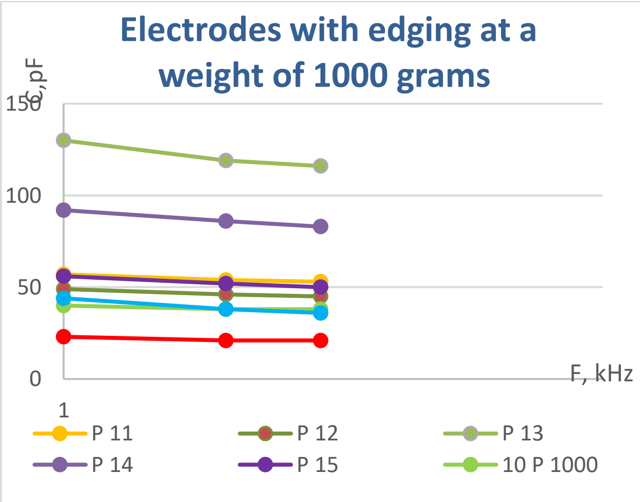

Fig.6: Electrodes with edging at a weight of 1000 grams

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TABLE 2 CHARACTERISTICS OF ELECTRODES WITH OR WITHOUT EDGING AT A WEIGHT OF 1000 GRAMS

Capacity pF / Frequency kHz	**New**					**10 washing cycles**	**50 washing cycles**	**treated with NaCl**
	P 11	P 12	P 13	P 14	P 15	10 P 1000	50 P 1000	NaCl P 1000
1 kHz	57	49	130	92	56	40	23	44
10 kHz	54	46	119	86	52	38	21	38
25 kHz	53	45	116	83	50	38	21	36
with edging weighing 1000gr								
1 kHz	283	286	279	306	273	237	115	256
10 kHz	256	259	253	274	247	213	95	233
25 kHz	249	252	250	267	233	207	90	226
without edging with a weight of 1000gr								

The obtained results which could see in Fig. 3, Fig. 4, Fig.5 and Fig.6 lead to the finding that the "aging" of the electrodes due to a certain number of washing cycles does not lead to large (within an order of magnitude) differences in the measured capacity. With a normal number of wash cycles required for the daily operation of a textile monitoring system in working conditions (up to 50 pieces), this capacity changes within up to two and a half times (250%), while the capacity scatters when measuring several new, untreated electrode is of the order of 100%. No change in capacity was observed when treating the electrodes with a saturated aqueous NaCl solution. At the same time, the differences in capacitance when measuring electrodes with edging and those without edging is significant - about 5 times. The reason for this is the practical impossibility of providing a minimum distance between the end of the textile electrode - where the area is largest - and the copper electrode.

IV. CONCLUSIONS

The measurements made prove the possibility of using textile electrodes built into the clothing, under standard operating conditions of the latter. When designing and manufacturing systems for capacitive recording of vital parameters, it is desirable to use unedged electrodes, due to their more uniform contact with surfaces.

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