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Fabrication Of Electronic Nose For Evaluation Of Performance Of Fragrance Finished Textiles

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Abstract

Fragrance finish is one of the innovative finishes that produce pleasant sensorial effects to the consumer and also fresh aroma to the textiles through its compounds both in natural form and synthetic.But these compounds are of volatile in nature and there is a need to maintain its durability by various techniques. The perfumes of lavender, rose, citrus or vanilla etcwere successfully encapsulated into fabrics and showed a good way to meet important psychological and emotional needs. Measuring aroma from this fabric becomes a difficult task in textile industry. Generally, the samples were sniffed through the panel of judges and they rank the samples based on the rating scales such as five point scale(0-5)which is known as sensorial analysis. Only few measurement methods are available for measuring the odor but none are without human participation which involves human error and inconsistency.

Hence to overcome the difficulties of sensorial perception, an electronic nose is developed, which is an emergent technology that closely resembles biological model and can be an ideal solution for the odor detection and discrimination problems. It is a device that entails an array of gas sensors and has the pattern recognition ability from the data analysis of whole set of sensor responses. This paper reveals an attempt to create an E-nose for reliable, simple and convenient objective measurement of fragrance finished textiles. An E-nose setup is created using Sno_2 gas sensor and it is tested to detect jasmine fragrance finished on 100% cotton fabric at three different concentration levels using successive approximation method. It is also used to evaluate the performance of the finish and its washing durability after repeated washing cyclesand finally, the analysis displayed the values of it in terms of percentage of retained fragrance compounds. From the results,it is proven to be the successful approach for detecting the durability of fragrance from the textiles and this trend has narrowed the gap between the complicated task of measuring the odor.

1. Introduction

Many innovative finishes have come through with specific functionalities to gratify the need of the market today. The addition of fragrances to textiles has been done to impart a fresh aroma to the textile. It induces various psychological effects and also sedative effects like anger, anxiety, emotion etc. It has numerous novelty applications such as children's garments, interior textiles such as draperies, curtains, upholsteries etc. In future, fashion garments may carry the smell of branded perfumes, particularly as many perfume houses have entered the world of haute couture. It can be finished with various techniques like padding, exhaustion and screen printing techniques. However, the fragrance which is finished on the fabric survived only 3 to 4 wash cycles. The most promising technique can be the microencapsulation where the life of the fragrance remained during a significant part of its lifetime.

Since 1979 R T Dodge of Dayton, ohio has been involved in the manufacture of microencapsulated sniff and scratch T shirts and in women hosiery. In general, the fragrance finishes applied on the fabric are evaluated using the rating scales, say 5 point scale where it ranges from no smell to very strong intensity. The participants were given the fabric to smell by taking two or three whiffs and are asked to rate the intensity. This sensory perception method involves human participation which may cause error due to fatigue and it lacks the repeatability of the analysis. So, there is a need to measure the fragrance intensity and its performance through an simple, fast and reliable objective measurement though few measurement methods like dilution to threshold level , Olfactometersetc are available but with human involvement. In present work, an attempt is made to create an electronic nose which uses sensor technology in order to overwhelm the difficulties in available methods. Here, Electronic nose consists of a sensor where the chemical input is converted into multidimensional patterns to detect the fragrances from the textile finished with fragrant smelling compounds. Recent applications of electronic nose technologies have come through advances in sensor design, material improvements, software innovations and progress in micro circuitry design and systems integration. Electronic noses have provided a plethora of benefits to a variety of commercial industries, including the agricultural, biomedical, cosmetics, environmental, food, manufacturing, military, pharmaceutical, regulatory, and various scientific research fields. Advances have improved product attributes, uniformity, and consistency as a result of increases in quality control capabilities afforded by electronic-nose monitoring of all phases of industrial manufacturing processes. Thus it can also measure the intensity of the fragrance after repeated washing cycles and evaluate wash fastness of any fragrance.

2. Materials

Dyed 100% cotton poplin was used for this study. The jasmine fragrance chemicals in the form of capsules and the binder were procured from Resil chemicals PvtLmt. Thirupur.

2.1 Fragrance finishing

The fabric was given finishing using exhaustion method at three different concentrations. The correct weight of the jasmine capsules was taken for application. The fabric is kept at the bath where the capsules (80% of the calculated surface area) and the binder (20% of the surface area) were added slowly with constant agitation in 1:30 material to liquor ratio at room temperature for 40 minutes maintained at 5.5 PH.

Table 1. Fabric parameters

Ends/ inch	110
Picks / inch	100
Count	60
Thickness	0.2
GSM	95
Weave	Plain

Then the fabric is taken, squeezed and dried at 80^{o}c in oven for 5 minutes. The fragrance finished samples was analyzed using Scanning Electron Microscope JEOLJSM-840a instrument. It was found that the fragrance molecules deposited uniformly on the fabrics and it is shown in fig 1.

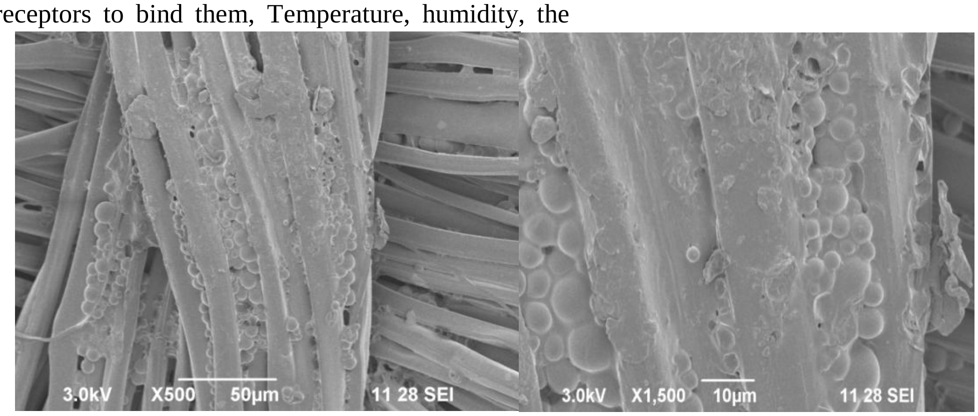

Fig 1. SEM analysis showing the deposition of jasmine fragrance molecules on the fabric.

2.2 Experimental setup

The fragrances are volatile compounds and it is difficult to measure it due to various factors including the compounds themselves, the olfactory receptors to bind them, Temperature, humidity, the matrix in which the chemicals are embedded etc. The presence of small amount of impurities may cause significant change in the fragrance detection process. In order to have an accurate measurement to the test fragrance, a characterization system is being developed. Hence due to theabove mentioned reasons, a test box is developed to characterize the sensor and the signals from it due to the electrical parameters of the sensor. The details of the experimental setup are described below:

2.3 Test box

The developed test box which is used to characterize the sensor under different environmental conditions is given in figure 2. The locally developed test box made of bakelite having total volume of 422 cubic cm kept at the metal base. Test box is provided with electrical connections for sensor characterization in presence of the jasmine fragrance from the finished sample. A small 5 V DC fan is fitted inside the box for homogeneous spread of the fragrance. Sno_2 based gas sensor is fitted as facing upwardsto sense the jasmine fragrance along with the dry air and is exhausted through the hole.

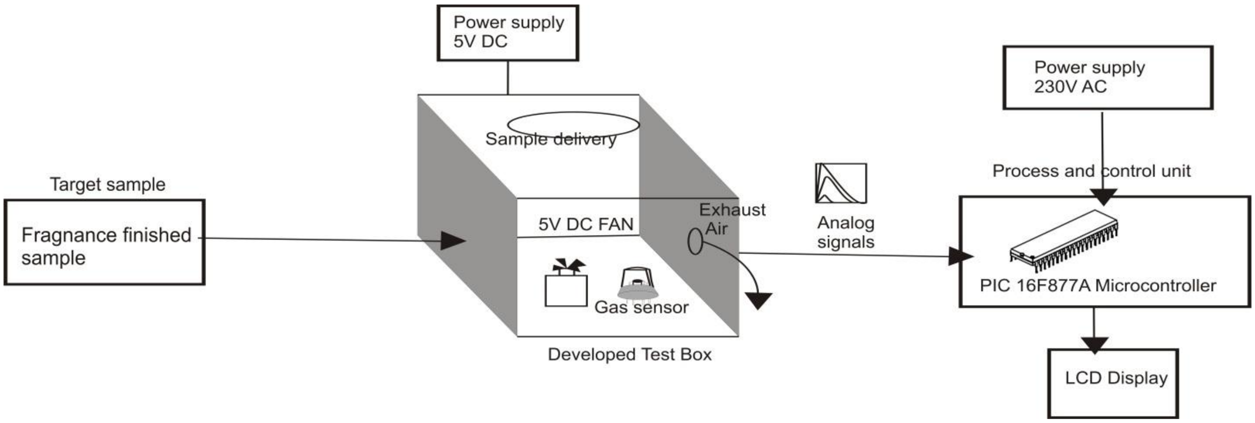

Fig 2. Schematic Diagram of Electronic Nose set up

2.4 Sensor

In this present work,Sno_2 based gas sensor model MQ 135 bought from Vashist technologies, Coimbatore for the measurement of the fragrance from the fabric. The sensor composed by micro AL_2O_3 ceramic tube, tin oxide (Sno_2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The sensor has 6 pin, 4 of them are used to fetch signals and the other two are used for providing heating current. The structure of the sensor is given in figure 3. The standard detecting condition can be Temp: 20±2Vc: 5V±0.1, Humidity: 65±5%Vh : 5V±0.1 and the sensing resistance can be 30 KΩ - 200 KΩ.

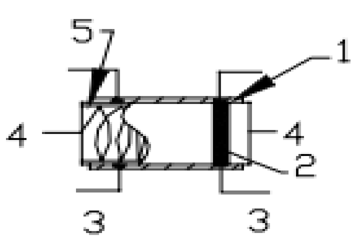

Fig 3. Structure of the Sno_2 based sensor 1- gas sensing layer(Sno_2) , 2-electrode (Au) , 3 – Electrode line (Pt) , 4- heater coil (Ni –Cr alloy) , 5- tubular ceramic (AL_2O_3)

2.5 Principle

The principle of the developed Electronic nose is described briefly below:

2.5.1 Sample delivery

The fragrance finished samples were cut into standard sizes of 5”x 5” based on the provided space in the test box. The test box was designed with the provision to keep the sample inside the box. The prepared samples were inserted into the partition when the display asked to keep the sample on the test box. When the fragrance finished samples kept inside the provision, the responses of the sensor changes to the time of exposure of the fragrance.

2.5.2 Fragrance detection

The finished sample was given jasmine fragrance consists of benzene derivatives and the sensor can detect the compound when it is exposed along with the dry air through the fan fitted inside the box. Firstly, the evaluated finished samples should be taken as the learning samples for proper training. The samples made in three concentrations and the number of samples in the training set is 36. In order to alleviate the disturbances from the environment, operating error, measuring circuits and the stability of the sensor etc., these samples from the same kind of fragrance should be measured. But these samples should be measured only one time since it can be oxidized in air. After learning and recollecting all the characteristics of the jasmine fragrance, the developed electronic nose can be used for the recognition, classification and the quantitative evaluation or concentration estimating tasks. In this work, only one sensor is trained to detect the fragrance with a specific sensitivity and selectivity for the measuring sample.

After the jasmine fragrance from the fabric was drawn into the box, it adsorbs on the active material or the sensitive membrane surfaces of the sensor which influences the physical parameters of the sensor. For each measuring sample, the sensor can produce multiple responding curves with respect to change in voltage Vs exposure time. Through filtering and A/D conversion, the maximum value of each curve is taken and it is transformed into multidimensional voltage response patterns. Then, by recollection of the corresponding relationships between the characteristics through analysis of components and the sensor responses, the electronic nose can swiftly produce the required results such as concentration according to the multidimensional patterns. The arrangement of electronic in the setup is shown in figure 4.

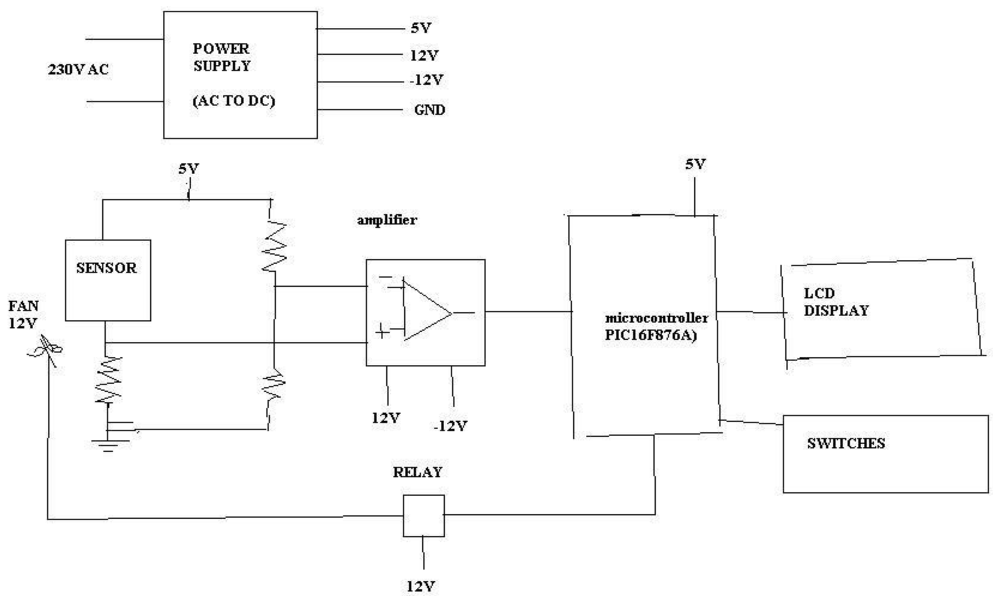

Fig 4. Electronics Arrangement of the set up.

2.5.3 Data processing and control

The sensor produces analog signals when the jasmine fragrance is recognized by it. The analog signals is then sent into the microcontroller where the data processing and control is done. When it enters the control unit, Microcontroller performs the conversion of analog to digital signals using 8 channels of 10-bit Analog-to-Digital (A/D) converter. Then, it enters Arithmetic logic unit where logical operations are done and finally the concentration values are displayed in LCD. The Program has also been designed to display the present-day values of concentration of the new samples. The block diagram showing the principle is given in figure5.

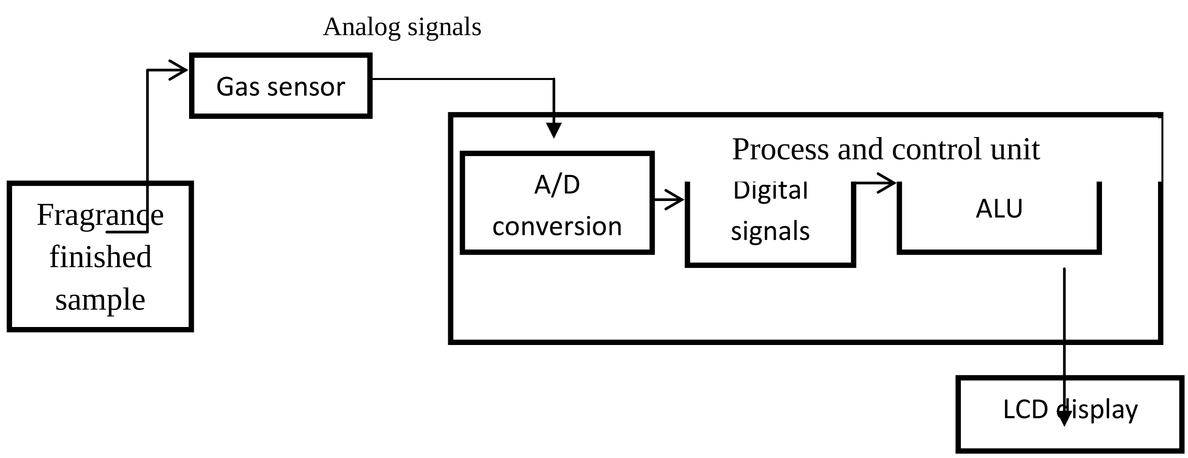

Fig 5. Block diagram of the principle of Electronic Nose

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2.6 Fragrance durability

The fragrance finished samples were prepared for evaluation. The samples were exposed to external environment and are collected to gauge its intensity with ageing.Washing durability was done byperforming washing and drying according to the standard AATCC 135 tests.[5]

2.6.1 Electronic Nose

The developed Electronic nose was used for the detection of the jasmine fragrance which produces the change in voltage when exposed to the sensor. The fingerprints associated with the sample is being given in the form of concentration of fragrance (gms) retained on the fabric. Then, the Percentage fragrance retention intensities werealso calculated with ageing andsubsequent washing cycles using Electronic Nose to evaluate the performance of the finish.The system is programmed to give the fragrance retention rate which uses the formula below:

Percentage Fragrance retention rate =100 – fragrance release rate (%)

Fragrance release rate (%)

$$= \frac{\text{immediate concentration} - \text{after 4 days}}{\text{immediate concentration}} \times 100$$

2.6.2 Human sensory test

The evaluation of fragrance was done by panel of 10 judges. The five point scale was first given to all judges to understand the rating scores and rank the test specimen. Evaluation was done for all the samples which were packed in an air tight polythene bag so that there was no release of fragrance in between evaluation due to air or light. Judges were allowed to take 3-4 whiffs for each sample in an open corridor and rank them in prepared 5 point scale. They were also given thesmell of strong coffee in between to neutralize smell of previous sample.[8]

The scale ranges from 0-5 where 0 represents No Smell , 1 - Barely perceptible, 2 - slight , 3 - moderate , 4 - strong , 5 - very strong.

The overall rating of fragrance intensity is calculated using the following formula:[16]

$$\text{Percentage aroma intensity} = \sum_{i=0}^{5} (S_i n_j / 4n) \times 100$$

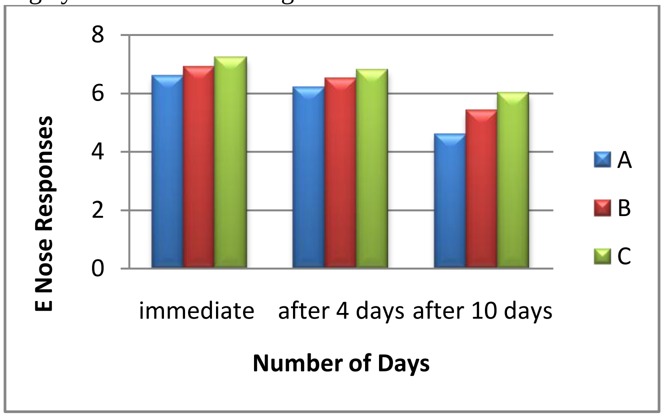
Where n = Total number of judges, S_i = Judge's rating, 5 = Highest rating, n_j = Number of judges giving rating S_i

Finally, the affiliation between the results obtained from E Nose and human panels were assessed using correlation technique which can reveal the relation among them.

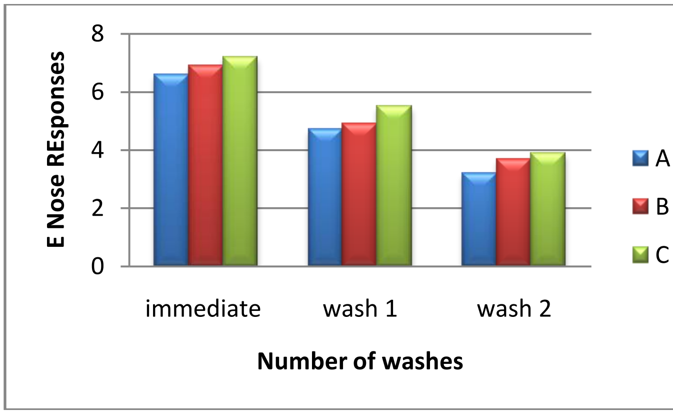
3. Results and discussions

3.1 E Nose responses to the levels of fragrance intensity

The E Nose responses to the jasmine fragrance finished samples with ageing and after repeated washing cycles are shown in figure 6.



a)



b)

Fig 6. E Nose responses towards fragrance intensity with a) ageing b) washingcycles atthree differentconcentrations. A- Concentration 1 (10 gms), B – Concentration2 (12 gms), C – Concentration 3(14 gms).

Fabric C shows strong aroma than A and B as the concentration is higher and also the fragrance molecules stronglybound on the fabric. The fabrics was also evaluated for durability and performance of the finish to washing and it is observed that the reduction of fragrance during subsequent washing cycles show greater fragrance release which depends upon the washing conditions and abrading of molecules in washing. Fabric A shows great fragrance reduction after repeated washing cycles than fabric B and C as the fragrance compounds deposited on the fabric is much lesser comparatively.

The percentagefragrance retention rates is calculated with the above concentration values for both ageing and washing durability which is given in table 2. It was proved that the fragrance retention rate depends upon releasing property. Fabric C has higher fragrance retention rate than others as its release rate was less comparatively.

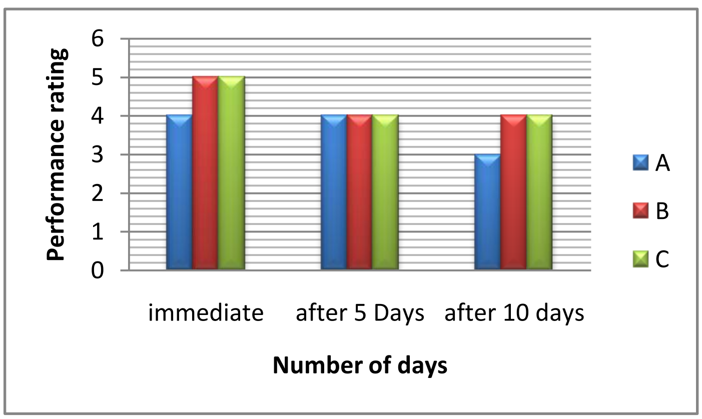
Fabric code	Fragrance retention intensity (%) After 5 days	After 10 days	After 1 wash	After 2 wash
A	93.94	68.13	68.08	43.55
B	94.21	77.28	71.01	46.53
C	94.40	82.63	76.38	47.28

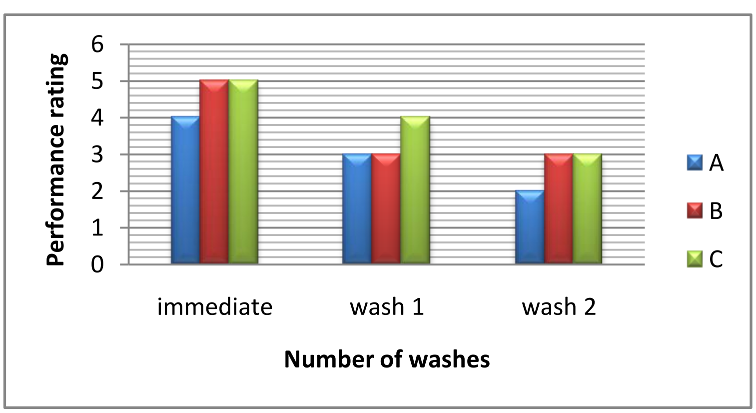
Table 2. Determination Of Percentage Fragrance retention.

3.2 Human sensory test

The fragrance from the fabrics was observed through the panel of judges and the average rating score was calculated which is given in fig 7.

a)





b)

fig 7. Performance rating scores from human sensory test with a)

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ageing b) washing cyclesat three concentrations.

It was observed that the fragrancein fabric B and C graded as very strong but fabric C retained well with ageing and repetitive washing cycles when compared with others same as the results from Electronic Nose . Fabric A expresses great fragrance reduction than fabric B. The calculated percentage fragrance intensity from the rated scores using the formula is shown in table 3.

	Fragrance retention intensity (%)				
Fabric code	Immediate	After5days	After10 days	After1Wash	After2Wash
A	84	78	72	66	56
B	88	80	74	68	58
C	92	82	76	72	60

Table 3. Determination of percentage fragrance retention from sensory test

The correlation of results showing thepercentage fragranceretention intensities obtained through Electronic nose and the human sensory test is givenin figure 8.

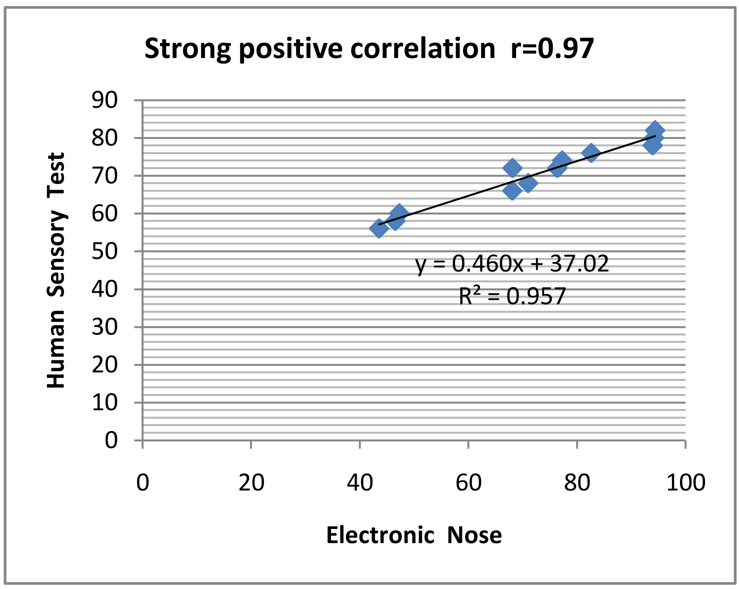

Fig 8. Correlation between percentage fragrance retention intensity rates obtained from Electronic Nose and Human sensory test.

It was found that fragrance retention intensity obtainedfrom Electronic Nose was strongly correlated with the fragrance intensity ratingscores from the panel of judges. These values are towards perfect correlation which indicates the relation between machine and the human olfaction. It also indicates the better ability of sensor based system to recognize the sample fragrance than human panels .

4. Conclusion

The developedElectronic nose was successfully attempted to detect the fragrance applied over the fabrics for Quantitative evaluation ofits durability over repeated washing cycles and ageing. The samples were tested through both Electronic nose and human sensory test. The experimental results shows that the fragrance intensity depends upon the concentration level as fabric C shows higher intensity and retention rate than fabric A and B.The valuation of fragrance intensity by human panels was hard to differentiate through their rating scores. The developed Electronic Nosehas been proved to have higher classification accuracyfor detectingfragrance finishedfabrics. The correlation between the percentage fragrance intensity determined throughElectronic Nose and human panels. The results proved that the target fragrance recognition through Electronic Nose for durability assessment was almost similar and remained reliable than the human sensory test rating scores obtained from the panel of judges.

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