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JEAS

JOURNAL OF ENGINEERING AND APPLIED SCIENCES

A Refereed Academic Journal Published by the
Publishing and Translation Center at Majmaah University

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مركز النشر والترجمة جامعة المجمعة
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THE MOST GRACIOUS,
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Editorial

Scientific publishing has brought many challenges to authors. With increasing number of scientific journals, varying scopes and reviewing requirements, and cost of publishing to authors, finding the right journal to publish an article is a decision many authors must bitterly confront and resolve. The publication of scientific findings is an integral part of the life of researchers; and the process of publishing has evolved to become an efficient system of decimating knowledge and collaboration among scientists. Science journals have institutionalized procedures to manage large volume of article submissions per year; in many cases, journals began to define narrower scopes for a dual purpose: managing submissions and delivering outstanding research.

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According to recent estimates, the number of scientific journals grows by 3% per year worldwide. With this large number of journals, journals may find it harder to stay afloat.

In its inauguration, the board of editors is honored to introduce to the scientific community the Journal of Engineering and Applied Sciences - JEAS, another scientific journal from Majmaah University. The board has pledged a commitment to JEAS authors and readers to bring the most dynamic and vibrant journal management with better satisfaction.

Dr. Sameh S. Ahmed

Contents

Investigating the Semi-batch Extraction of $KHCO_3$ from Polyamide-6 Pellets

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Abstract

The extraction of potassium bicarbonate from the microporous polyamide-6 pellets feed using a semi- batch extractor has been investigated. The effects of solvent flow rate, solvent temperature, and feed mass on the extraction of solute have been analyzed. As solvent rate increased, the conductivity of miscella increased, and at highest solvent rate of 160 mL/min a maximum solute concentration of 1.9 wt. % $KHCO_3$ was achieved. The maximal concentration of 2.3 wt. % $KHCO_3$ was observed at a solvent temperature of 318 K at a batch processing time of 120 seconds. The conductivity of miscella also increased with increased feed masses. Further, the solute concentration in the miscella increased with increased feed masses, and a maximum solute concentration of 2.1 wt. % was achieved at a feed mass of 0.13 kg during the initial stage of extraction. Use of the best operating conditions will optimize the extraction of potassium bicarbonate from polyamide-6 pellets feed on a large scale

Keyword: Polymide-6: Potassium bicarbonate: Miscella: Oprtating conditions.

Article history: Received:April 5, 2017; Accepted: December 12, 2017

1. Introduction

Many chemical processes are characterized by an industrially important solid-liquid extraction. The feed is contacted with a solvent in order to separate the desired component. The solid and the solvent remain in close contact, and the desired solute can diffuse from the solid to the liquid, which leads to a separation of components initially present in the feed [1]. The solute diffuses from the solid feed into the nearby solvent. Either the leached solid or insoluble solid, or both, may be a valuable product [2]. The solid-liquid extraction, also known as leaching, is extensively used in food-processing industries. Solids (feed) may undergo considerable change in their characteristics during the leaching operation [3].

The rate of extraction process is influenced by several factors. First, the size of feed particles is pertinent. More specifically, the range of feed particle size must be small enough that every particle requires approximately the same extraction rate. The solvent chosen should be highly selective and must possess low enough viscosity to ensure that it flows easily. The solubility of the solute to be extracted from solid feed increases with increased temperature thus, yielding a higher extraction rate.

Moreover, the diffusion coefficient increases with increased temperature, hence improving the extraction rate. Solvent agitation is industrially important because it leads to increased eddy diffusion, thereby increasing the transfer of solute from the surface of feed particles to the bulk of the solution. The success of solid-liquid extraction and the techniques to be employed will vary depending on the pretreatment of feed samples [4]. A comparative study of potassium bicarbonate extraction from polyamide feed using batch and single-stage continuous process has been conducted by Danish et al. 2016 [5]. It was concluded that the batch extractor performed better than a continuous one. Poirot et al. 2007 studied the counter-current continuous and batch extractions using vegetable substrate and concluded that the ratio of solid to liquid decreased by a third compared with usual conditions [6]. Jokic et al. 2010 studied the effect of the solvent type, temperature, and extraction time on the extraction of total polyphenols from soybeans. The maximum extraction yield was achieved at 353 K using 50% aqueous solution after 120 minutes of batch time [7]. Spigno et al. 2007 further studied the effects of different operating conditions on the extraction yield [8]. A study [9] devoted to the extraction of oil from jatropha seeds using microwave treatment and ultrasound assisted methods has been carried out and it was suggested that these methods have positive effect on the yield. The significance of current study is to analyze the influence of operating parameters on the extraction of potassium bicarbonate from porous polyamide pellets and the findings of the study may be used to suggest the best operating condition to optimize the extraction process.

2. Materials and Methods

2.1. Chemicals

$KHCO_3$ and polyamide pellets (average size 2.68 mm) from Sigma-Aldrich were employed to prepare the feed for extraction. Distilled water was used as a solvent to carry out extraction of the potassium bicarbonate extraction.

2.2. Experimental Set-Up

Fig.1 is a set-up diagram of the solid-liquid extraction unit procured from Armfield (U.K.) that was utilized for conducting the experimental work. The acrylic extraction unit is configured as a batch extractor, and flow rates of the solvent for extraction were adjusted using peristaltic pumps.

Temperature controller was used for fixing the desired set point temperatures of the solvent. The temperature of the solvent and the solute concentration in terms of wt. % $KHCO_3$ of extracted potassium bicarbonate in miscella were monitored by a temperature sensor and flow-through conductivity probe.

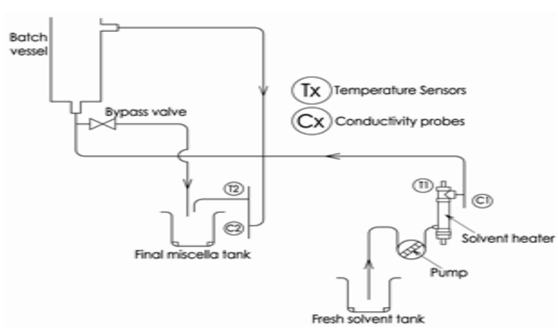

Fig.1. Set-up diagram of solid-liquid extraction unit

2.3 Experimental Procedure

Microporous polyamide-6 pellets containing potassium bicarbonate were used as feed material. First, microporous polymer pellets were dried completely using an oven set no higher than 333 K. Next, 500 grams of potassium bicarbonate was dissolved into 1.5 L of distilled water at 293 K, using a 3-liter batch of pellets (~ 400 gm) for one run as it was convenient to handle in a 5 L capacity graduated beaker. After this, the solution of $KHCO_3$ was added to 3 liters of dried polyamide-6 pellets (equivalent to 3 litres of volume, ~ 400 gm), and the mixture was stirred until the pellets were completely wetted out with the solution.

In order to absorb the solution, the polyamide-6 pellets were left for almost 24 hours and the mixture was stirred regularly to dispense the solution evenly. The wetted pellets were spread out on the drying trays and dried in an oven set no higher than 333 K. The dried samples were weighed, and their composition (51.5% by weight) was determined and a little amount of prepared $KHCO_3$ solution remains unabsorbed. Similar batches of feed were prepared for each run to investigate the effect of operating conditions on extraction. The peristaltic pump was calibrated so that exact solvent flow rates could be adjusted and controlled. The conductivity of the (miscella) was monitored and recorded using conductivity meter at regular intervals. The developed pictorial relationship (Fig.2) between the different $KHCO_3$ concentrations (wt.%) and conductivity (S) was used to tabulate the solute concentration in miscella.

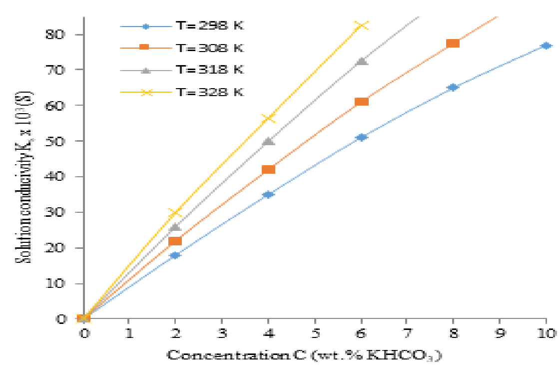

Fig.2 Conductivity vs solute concentration curves

3. Results and Discussion

3.1 Calibration Curve

The peristaltic feed pump was calibrated so that the actual solvent flow could be related to the setting of the rotary speed control. Calibration curve of flow rate Q (mL/min) versus speed setting R was used to adjust and control any desired solvent flow rate.

3.2 Solvent Flow Rates

Superior characteristics of pores play a significant role in the absorption of $KHCO_3$ into the porous pellets. Higher pore density and pore volume contribute to more absorption of extractable material from the solution in the porous pellets. Firstly, in the process of leaching, the solvent permeates through the bed of feed. Then, the extractable material on the surface is easily washed off by the solvent and thereafter, the $KHCO_3$ holdup within the porous feed is continuously dissolved by the solvent. Thereafter solute transfers through pores in the pellet to outside of particle by diffusion. At the end, the extractable material at the surface of porous feed diffuses into the steady layer of the solvent in feed particles and finally mixes with bulk of the solution.

The data were collected at a constant solvent temperature of 298 K with a feed mass of 0.11 kg. The solvent flow rates of 100 mL/minute, 130 mL/minute, 160 mL/minute, and 190 mL/minute were selected to investigate the effect of solvent flow rate on solute extraction. The dependence of miscella (extract) conductivity on batch time at different flow rates is shown in Fig. 3.

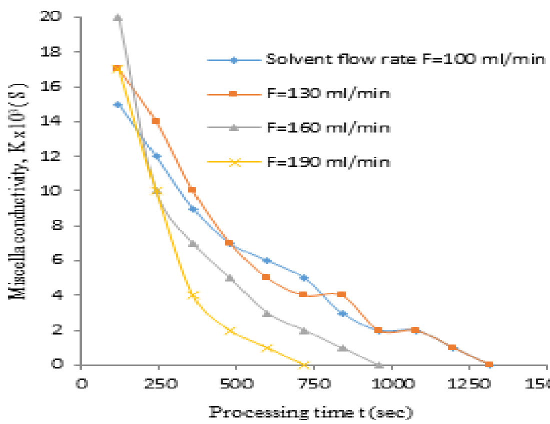

Fig. 3. Dependence of conductivity on time at different solvent flow rates

The maximum miscella conductivity of 20×10^{-3} S was observed at a batch extraction time of 120 seconds with a solvent rate of 160 mL/minute during the initial period of extraction. Conductivity decreases with increased batch processing time until the complete removal of extract from the feed samples. The minimum conductivity of 15×10^{-3} S was recorded during the initial period at a selected solvent flow rate of 100 mL/minute. Batch processing time required to reduce the conductivity to almost zero decreased with increased solvent flow rate within the studied range. The batch processing required to reduce the conductivity to zero S decreases from 1320 seconds to 720 seconds with the increased solvent flow rate from 100 mL/minute to 160 mL/minute. A batch processing time of 960 seconds at a solvent flow rate of 160 mL/minute was required to reduce the miscella conductivity to zero.

The dependence of solute concentration in terms of wt. % $KHCO_3$ is shown in Fig. 4. Solute concentration in the extract increases with increased solvent flow rate from 100 mL/minute to 130 mL/minute and then decreases at a flow rate of 160 mL/minute. The batch time required to extract all $KHCO_3$ decreases with increased solvent rate. The highest solute concentration of 1.9 wt. % $KHCO_3$ was obtained with a solvent flow rate of 160 mL/minute at a batch processing time of 120 seconds; this decreased to 1.1 wt. % $KHCO_3$ at a batch process time of 240 seconds.

The extraction rate of solute decreases with increased batch processing time because the amount of solute left in the feed decreases as the process progresses towards completion. The complete removal of extract requires a batch time of 120 seconds at a solvent flow rate of 190 mL/minute compared with a batch processing time of 1320 seconds at a solvent flow rate of 130 mL/minute.

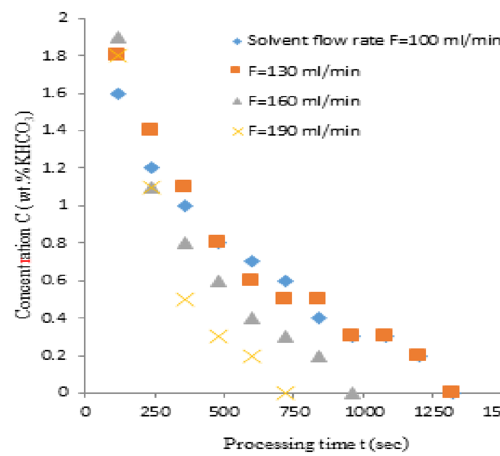

Fig. 4. Dependence of solute concentration on batch time at different solvent flow rates

3.3 Solvent Temperatures

All data were collected at a solvent flow rate of 100 mL/minute and with a feed mass of 0.11 kg. Four different solvent temperatures—298 K, 308 K, 318 K, and 328 K—were chosen to study the effect of temperature on extraction efficiency. The dependence of miscella conductivity on batch processing time is shown in Fig. 5. The conductivity of miscella decreases with increased batch processing time until a solvent temperature of 318 K and then decreases with batch time.

The maximum miscella conductivity of 27×10^{-3} S at a solvent temperature of 318 K and the least conductivity of 21×10^{-3} S under a constant solvent temperature of 298 K were recorded during the initial period of extraction at a batch time of 120 seconds. Higher initial conductivity values are the indicators of a large amount of solute in the fresh feed samples, and conductivity values are reduced to zero after a batch processing time of 1560 seconds for all cases of different solvent temperatures. Investigators concluded that miscella conductivity increases with increased temperature up to a solvent temperature of 318 K and conductivity declines at a solvent temperature of 328 K.

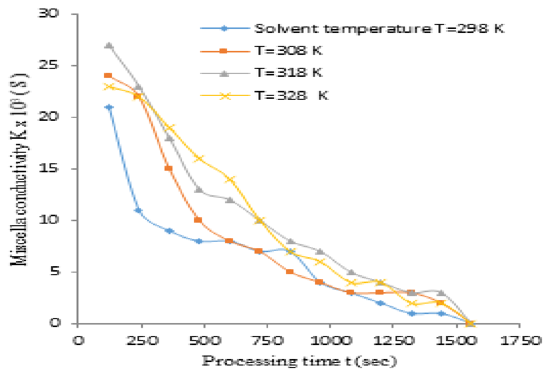

Fig.5. Dependence of miscella conductivity on time at different solvent temperatures

The variation of $KHCO_3$ concentration with batch processing time is shown in Figure 6. The amount of potassium bicarbonate in miscella declines with increased batch processing time. High solute concentrations of miscella were achieved during the initial period of extraction at a batch time of 120 seconds, because a significant amount of solute was initially present in the feed at all solvent temperatures.

The rate of extraction depends on the amount of extractable material remaining in the feed. The maximum solute concentration of 2.3 wt. % was obtained with a solvent temperature of 308 K at a batch time of 120 seconds, and concentration decreased to 1.5 wt. % at a batch processing time of 480 seconds. Solute was removed completely from the feed samples at a batch processing time of 1560 seconds. At all solvent temperatures, higher extraction rates were observed initially; this is due to the fact that the rate of extraction depends on the amount of solute left in the feed. Higher initial solute concentration in the feed samples leads to a higher extraction rate of solute from the feed.

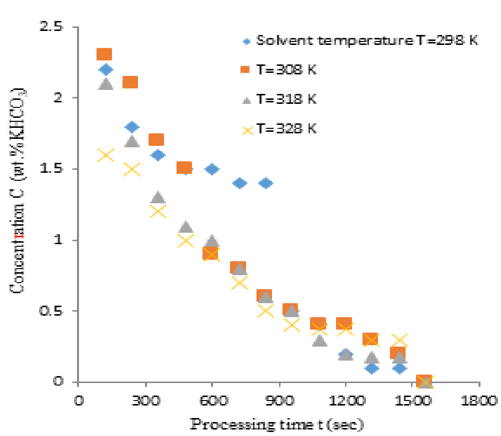

Fig. 6 Dependence of solute concentration on batch time at different solvent temperatures

3.4 Effect of Feed Masses

Data were collected at a solvent temperature of 298 K with a solvent flow rate adjusted to 100 mL/minute. The variation of miscella conductivity with batch processing time is shown in Fig. 7. The conductivity of miscella decreases with increased batch processing time, and almost complete removal of extract was achieved at batch processing periods of 960 to 1080 seconds. Higher conductivities were recorded during the initial period of extraction under all conditions of different feed masses.

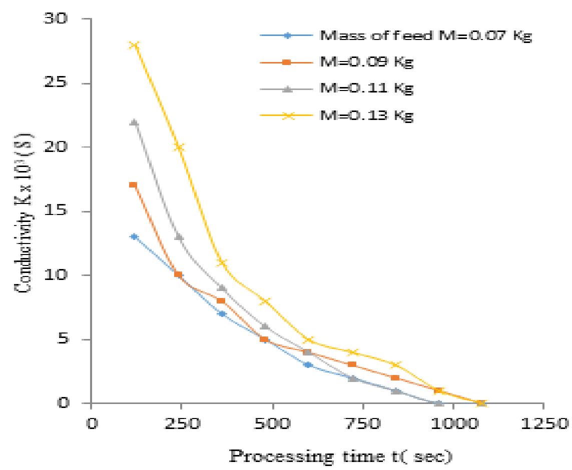

Fig.7. Dependence of miscella conductivity on processing time at various feed masses

Miscella conductivity increases with increased feed masses. Miscella conductivity increases from 13 S to 28 S on increasing the feed mass from 0.07 kg to 0.13 kg at a batch processing time of 120 seconds during initial stage of extraction. Increased mass of feed sample owing to high solute concentration contributes to higher miscella conductivity. Miscella conductivity decreases from 22 S to 13 S with increased batch time from 120 seconds to 240 seconds at a feed mass of 0.11 kg.

Fig.8 shows the dependence of wt. % $KHCO_3$ concentration on batch processing time under different conditions of feed masses. Higher extraction rates were achieved during the initial period of extraction. The solute concentration in miscella decreases with increased batch time as concentration of the $KHCO_3$ declines with the progression of the process, whereas the solute concentration in miscella increases with increased feed mass due to increased mass of $KHCO_3$ in the feed.

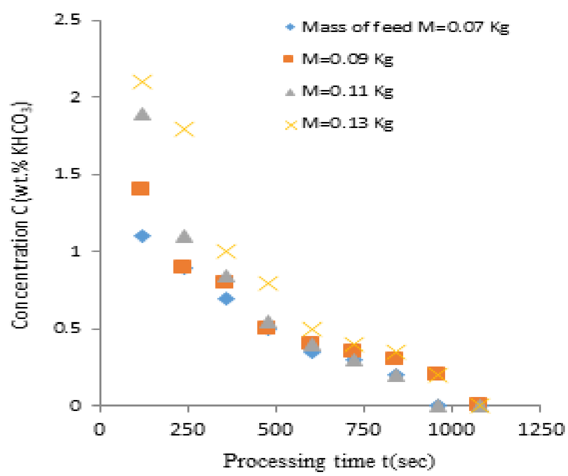

Fig. 8 Dependence of concentration on processing time at various feed masses

The increase of feed mass leads to increased solute material in the feed samples. The highest concentration of ~ 2.1 wt. % $KHCO_3$ was reached at a feed mass of 0.13 kg compared with a concentration of 1.9 wt. % at a feed mass of 0.11 kg during the initial period of extraction at a batch time of 120 seconds.

Sodium bicarbonate concentration of ~ 1.1 wt. % was obtained with a feed mass of 0.07 kg at batch processing time of 120 seconds, and the complete removal of solute was achieved after a batch time of 960 seconds. It was found that extraction rates decline with processing time due to decreased mass of extractable material in feed. With all feed masses, almost complete removal of extractable material was achieved at the end of batch processing periods of 960 to 1080 seconds.

4. Conclusions

The conductivity of miscella (extract) increases with increased solvent flow rate up to a solvent rate of 160 mL/minute. Its maximum value is 20 x10^{-3} S at a solvent flow rate of 160 mL/minute and decreased to 17 S at a solvent flow rate of 190 mL/minute. The batch processing time required to extract the solute decreases with increased solvent flow rate. Therefore, it is not always desirable to select a high solvent flow rate. The maximum sodium bicarbonate concentration of 1.9 wt. % was achieved with a solvent rate of 160 mL/minute at a batch time of 120 seconds compared with other selected solvent rates. The miscella conductivity increases with increased temperature from 298 K to 318 K, and its maximum value was recorded at a temperature of 318 K.

Under the conditions of different solvent temperatures, high extraction rates were achieved during the initial period of extraction. The highest sodium bicarbonate concentration of 2.3 wt. % in miscella was obtained at a solvent temperature of 308 K. High solute concentrations in the fresh feed samples lead to higher extraction rate during the initial stage of the extraction process. The conductivity of miscella increases with increased feed masses, and maximum conductivity of 28x10^{-3} S was recorded for a feed mass of 0.13 kg at a batch processing time of 120 seconds. High extraction rates were achieved during the initial period of extraction under different conditions of feed masses. The solute concentration of miscella increases with increased feed masses. The findings of the current research work may be used to optimize the extraction of potassium bicarbonate from polyamide-6 pellets from feed.

Acknowledgement

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Vanadium Complex (VO_2(3-fl)) Films Based Resistive Temperature Sensor

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Abstract

A resistive-type temperature sensor based on vanadium complex (VO_2(3-fl)) film is reported in this study. Silver electrodes were deposited on the glass substrates in a co-planar structure. A thin film of vanadium complex (VO_2(3-fl)) was coated as a temperature-sensing material on the top of the pre-patterned electrodes. The temperature-sensing principle of the sensor was based on the conductivity change of coated sensing element upon heating or cooling processes. The resistance of the temperature sensor, measured at 100 Hz, decreased exponentially with increasing the temperature in the range of 25−80 °C. The overall resistance of the sensor decreases in 3.7−4.5 times. The resistance temperature coefficients of the sensor were in the range of 3.2 to 3.6%. The properties of the sensor studied in this work, make it beneficial to be used in the instruments for environmental monitoring of temperature.

Keywords: Vanadium complex, thin film, teperature sensor, resistance;

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1. Introduction

Development of the sensors for application in monitoring various parameters such as humidity, temperature and chemical gases have gathered considerable attention in recent years. A number of sensors have been fabricated on the basis of vanadium oxides [1-6]. Vanadium oxides (VO_2) show the large reversible change of electric, magnetic and optical properties at temperatures around 68−70 °C [7-9]. Transition of semiconductor to metal is also observed in these smart materials. At transition temperature, the optical properties of vanadium dioxide are quickly changed: the optical transmission is decreased and reflectivity is increased. Due to this behavior, vanadium dioxide is an attractive material for smart windows for solar energy control and electrical and optical switches. Microstructure and crystallinity of the films effect hysteresis of the transition. By the addition of transition metals such as niobium, molybdenum or tungsten, the transition temperature of vanadium dioxide may be decreased.

It was found that VO_2 films demonstrate holographic storage and bit recording properties at using a near-infrared laser [10, 11]. Switching time of about 30 ns and writing energy of the order of a few mJ/cm^2 were reported [12]. The vanadium dioxide is an interesting candidate for modern applications of active thin films in optical or electric switches as well [13].

Vanadium oxide is considered as an n-type semiconducting material [7]. Due to the semiconducting properties, vanadium oxides and their complexes have been reported to be used in different kind of sensor. The lamellar nature of vanadium oxide makes it possible to modulate the adsorption and conduction properties. The electrical conductivity in vanadium oxides can be enhanced by formation of oxygen vacancies. Therefore it is important to introduce different metal based materials into existing technology which may bring in considerable improvements in functionality and/or cost of organic electronics [14]. A vanadium complex (VO_2(3-fl)) and CNT composite film based temperature sensor was reported in Ref. [15].

This paper reports the fabrication of surface-type Ag/VO_2(3-fl)/Ag resistive temperature sensor employing vanadium complex VO_2(3-fl) as an active sensing element.

2. **Experimental Procedure**

The molecular structure of the vanadium complex (VO_2(3-fl)) is shown in Fig. 1. The VO_2(3-fl) was obtained from Aldrich and used as received. Commercially available glass slides were used as substrates which were primarily cleaned ultrasonically. In the first go, the silver electrodes were deposited in a co-planar structure by masking on the glass substrate using Edwards AUTO 306 vacuum evaporation technique. The pressure inside the chamber was maintained at 10^{-5} mbar. The thickness of the silver electrodes was 200 nm. It was measured in the process of the thin film deposition by quartz crystal oscillator, FTM5, which was fitted in the vacuum evaporator chamber. The gap between the silver electrodes was 40 µm. It was measured by optical microscope with built-in scale. Later, 5 wt.% solution of VO_2(3-fl) in benzol was drop casted on the pre-patterned Ag surface-type electrodes. The device was kept at room temperature for 10 hrs to let the moisture evaporate from the films. The VO_2(3-fl) film thickness was in the range of 20‒30 µm. The cross sectional view of the fabricated resistive type temperature sensor is shown in Fig. 2. The temperature measurements were carried out in a self-made chamber which has been designed and developed in our laboratory. The temperature range of 25 ˚C to 80 ˚C was selected due to its practical importance in domestic and industrial applications. Resistance measurements were carried out using ESCORT ELC-132A meter at a frequency of 100 Hz in ambient atmosphere. The temperature was measured by multi-meter FLUKE 87. The experimental error for the measurement of the temperature was equal to ±1 ºC and the accuracy of electric resistance measurement was equal to ±2% (it was estimated as described by Dally et. al. [16]).

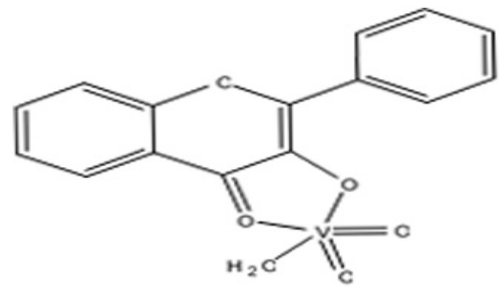

Fig. 1: Molecular structure of the vanadium complex VO_2(3-fl).

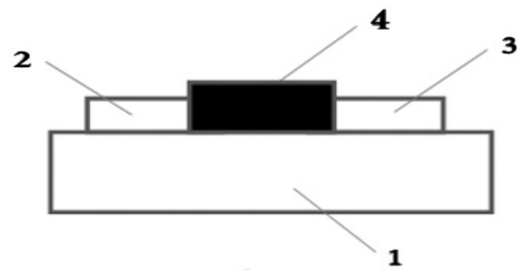

Fig. 2: The cross sectional view of the fabricated resistive type temperature sensor: Glass substrate (1), Silver electrodes (2 and 3), VO2(3-fl) film (4).

3. Results and Discussion

Fig. 3 shows resistance versus temperature relationships for two Ag/VO_2(3-fl)/Ag surface–type resistive temperature sensors. It can be observed that the resistances show sharp decrease with increase of temperature that is actually characterize semiconductor based thermistors [16]. The resistance of the temperature sensors decreases 3.7‒4.5 times with increasing the temperature in the range of 25‒80 ºC. At heating or cooling processes, resistance-temperature curves of the sensors show good repeatability. The resistance temperature coefficient (S) of the samples can be calculated by [16]:

$$S = \frac{\Delta R \times 100\%}{R_o \Delta T} \quad (1)$$

where R_o, ΔR and ΔT are initial value of the sensor's resistance, changes in the resistance and temperature, respectively. It was found that the resistance temperature coefficients of the sensors were in the range of 3.2 to 3.6% .The value of the resistance temperature coefficients are in the range of that of conventional semiconductor thermistors [16].

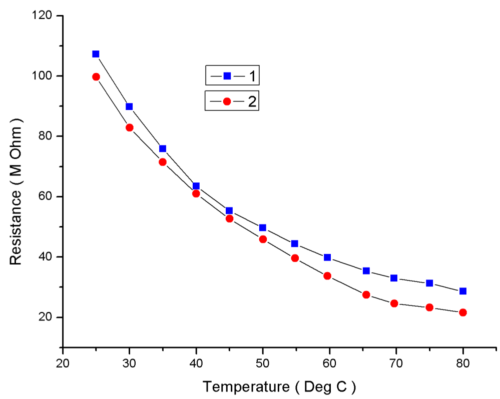

Fig. 3: Resistance versus temperature relationship for two Ag/VO_2(3-fl)/Ag surface–type resistive temperature sensors.

For simulation of the resistance-temperature relationships, we can use an exponential function given in Eq. (2) [17] by method of substitution.

$$f(x) = e^{-x} \quad (2)$$

The relative resistance –temperature relationships can be expressed by the following equation:

$$\frac{R}{R_o} = e^{-\Delta TK} \quad (3)$$

where R is the sample's resistance at elevated temperatures (T), K is the resistance temperature factor. Average value of K was determined from the experimental data shown in Fig. 3, which is 2.6×10^{-2} °C^{-1}. Fig. 4 shows the experimental and simulated (by using Eq. (3)) results, which are in good agreement.

The mechanism of conductivity in the VO_2(3-fl) samples can be considered as transitions between spatially separated sites that can be attributed to the Percolation theory [18,19]. According to Percolation theory, the effective conductivity (σ) of the samples can be calculated as:

$$\sigma = \frac{1}{LZ} \quad (4)$$

where L is a characteristic length, which depends on the concentration of sites, Z is the resistance of the path with the lowest average resistance. With an increase in temperature, the sample is heated that may cause the reduction of Z due to generation of charge carriers, increase of their concentration and mobility. The conductivity of the VO_2(3-fl) samples increases and the resistance decreases with increase of temperature accordingly, as observed experimentally (Fig. 3).

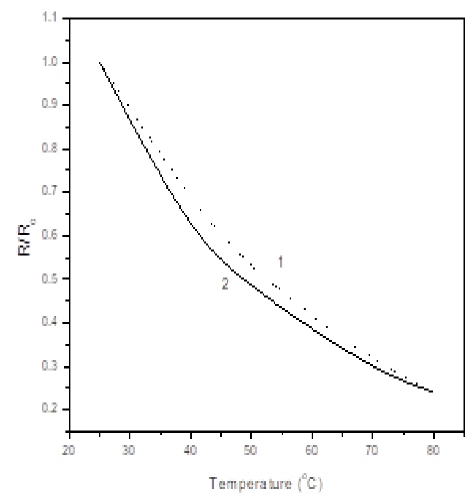

Fig. 4: Simulated (1) and experimental (2) resistance versus temperature relationship for Ag/VO_2(3-fl)/Ag surface–type resistive temperature sensor.

As experimental resistance-temperature (Fig. 3 and Fig. 4) relationships for the VO_2(3-fl) sensors are quasi-exponential, they can be easily linearized by nonlinear op-amps [20].

4. Conclusion

The resistive-type temperature sensor based on vanadium complex was fabricated by drop-casting method from solution of VO_2(3-fl). It was found that resistive-temperature relationships of the sensors showed exponential behavior. The resistance temperature coefficients of the sensors were in the range of 3.2 to 3.6%. The mechanism of change of conductivity with change of the temperature in the VO_2(3-fl) was considered as transitions between spatially separated sites that can be attributed to the Percolation theory: with an increase in temperature, an increase in the concentration and mobility of charge carriers take place.

Conflict of Interest

None declared

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An Architecture of a Cloud-Based Virtual Learning Environment

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Abstract

In recent years, the use of e-learning in the higher education sector in Saudi Arabia has increased, as it offers many advantages compared to traditional learning; for example, by enabling students to access e-resources anywhere and at any time. Each individual university has its own e-learning system (tools) that receive significant financial investment. However, there is no integration between these systems. The cloud computing can be used in this area as it offers the advantages of facilitating knowledge-sharing and providing different platforms. In this paper, an architecture of a Virtual Learning Environment that supports different e-learning platforms is proposed; the proposed system is based on cloud computing, as it offers many advantages to universities, educators and students. This research aims to show that how cloud computing may be used to support educational domains. Cloud computing is likely to have considerable impact on education in the future and to address .many challenges facing the sector

Keywords: E-learning; Virtual Learning Environment; Cloud computing

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1. Introduction

The use of Virtual Learning Environments has increased in recent years in Saudi Arabia. It is a rapidly developing area, especially in education, as many universities have invested in VLEs to further develop the courses they offer. In this type of learning, instructors and learners live in different places [1]. As instructors and learners do not meet face-to-face, they do not engage with each other in a classroom environment; however, they meet in a virtual location called a Virtual Learning Environment. Students are taught without having an instructor in the classroom. Instead, material is designed by tutors and presented it in a virtual space [2]. VLE are also known as Learning Management Systems (LMS).

However, there are some major limitations to the current VLE systems used at Saudi universities. Universities sometimes pay too much to buy VLE systems. In addition, each university has a separate e-learning system that offers no integration with the VLE systems used in other universities; therefore, there is a need for further integration between the VLEs used at Saudi universities. This paper suggests using cloud computing to resolve this issue, which offers a number of advantages that could help address these limitations. Cloud computing technology offers services and allows users to make demands and provide the services they require. It has grown over the past few years around the globe to provide services and tools to users. The main concept of cloud computing is to provide access to platforms and applications via remote servers. In more detail, cloud computing technology allows access to businesses without having to install applications on a device [3]. It is important to understand the basic concepts of cloud computing. The greatest important advantage of cloud computing is that it enables access to advanced technology and infrastructure without the need for a significant financial outlay. Furthermore, it facilitates the sharing of knowledge and resources between academic institutions [4]. The rest of this paper is organized as follows: Section 2 presents literature review of Virtual Learning Environments, and Section 3 discusses cloud computing in depth. Section 4 presents the proposal architecture, and the conclusions are presented in Section 5.

2. Virtual Learning Environment

Many researchers have defined their own view of VLE. The UK's Joint Information System Committee [5] has defined VLE as "an electronic system that can provide online interactions of various kinds that take place between learners and tutors, including online learning". According to [6], the VLE is a software system that can be used to deliver online education via web-based content, such as, chats ,automated tests and discussion forums. The low cost is not the only reason to use VLEs; they can also be modified to address the teaching needs of a particular course. Several types of open source software can be used to develop VLEs. One of the most common is the Moodle system.

VLEs offer many advantages that have been described in the literature. With increasing numbers of students in higher education around the world, VLEs can support universities to cut the practical pressures of finding sufficient physical resources and space for them. Students can study their course modules at anytime and anywhere, unlike in traditional learning environments [7]. Regarding fixed time and space constraints; some learners prefer not to have a fixed time or place for learning, and VLEs can be appropriate for their learning style. Learning and teaching using VLEs is extra economic than old-style learning, as students are able to study from home without expenditure money on transportation to university. VLEs can deliver education to people who have experienced barriers, such as students who have singular requirements or a disability. In addition, learners who have family commitments or individuals with financial difficulties may find it easier to participate in the learning environment using a VLE [8].

Educators have the ability to manage courses in a VLE system, for example, by sending announcements to students, issuing assignments and uploading course material [2]. VLEs can offer student services, such as discussion boards, document-sharing and access to off-line lectures or notes. VLEs can link course contributors to reach both effective collaboration and communication. Finally, students and lecturers may appreciate the suitability of the online sending of resources and materials [9].

Because VLEs are an important practical and inexpensive new product for higher education, many Saudi universities have developed their own VLEs, such as Blackboard, Moodle, and D2L. However, over 30 universities use VLEs, each with their own spearheaded system, which means paying individually for both the tools and license. The greatest drawback is the lack of integration between these VLEs, as sharing course content would save time and effort.

Each university has its own data center with servers, a storage space, network devices and other equipment. In additional to the system administrators required to control all the servers, there is a need to integrate these VLEs between different universities. Increased collaboration between them would be beneficial to all institutions involved, especially to those that cannot afford technical support staff to maintain their systems. Therefore, collaboration between institutions in the use of the different techniques would be very helpful. Many institutions do not have enough staff to maintain their systems and to provide the necessary technical support. There is a need for an architecture with multiple features, such as integrity, availability and scalability. The core business of Saudi universities is to provide education to students. They are shifting away from considering IT operations to spending time and effort on IT infrastructure. Cloud computing is a new trend in computing technology that can help address these issues.

3.Cloud computing

Depending on user requirements, cloud computing proposals a range of services, and allows users to provide some services and to formulate their own demands. In recent years, the use of cloud computing has grown around the world. The main concept of cloud computing is to provide access to devices, platforms and applications via a remote server. Over the past few years, the environment of the internet has continued to move from a static to a extremely dynamic environment that permits users to run software applications and collaborate to share information and create new facilities online. Cloud computing has improved in use due to the large number of features it offers, and many business models rely on cloud computing to deliver their services to customers [5].

There are several definitions of cloud computing; the most suitable and commonly used one is that of the National Institute of Standards and Technology [9], "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models". Another definition for cloud computing is presented by [10], "A style of computing in which massively scalable IT related capabilities are provided as a service using Internet technologies to multiple external customers".

Cloud computing is a new technological trend in which a unique data center offers many service and tools to users [3]. Some of the features and advantages of cloud computing are described below. Cloud computing has ability to reduce institutions' expenditure as they need not individually build their own separate data centers but can share them instead. Virtualization is the main concept of cloud computing, as there are many issues involved in the use of physical servers. Cloud computing can resolve any issues that arise with physical servers by creating a virtual environment. If there is a problem with the fixed data center, data will be automatically moved to another environment. Data in the cloud does not need to be centralized to be consistent but is instead distributed, and users do not have to worry about their data if a failure occurs on any server [11].

Cloud computing includes three main service layers, which are software as a service, platform as a service and infrastructure as a service. Software as a Service (SaaS) refers to the software and applications that people can access over a web browser. Service providers control these applications without any cost control for the end user, for example Gmail and Hotmail. Platform as a Service (PaaS) refers to the environment that supports the applications and runs on the cloud. Infrastructure as a Service (IaaS) is located in basic environment of the cloud and includes hardware and resources for example, physical servers, storage and networks [12].

Many companies provide cloud services around the world, for example Google Apps, Microsoft Live@edu for education and Amazon web services for education [13]. The main IT vendors, such as Microsoft, Google, IBM, Yahoo and Amazon, are still building up their cloud. Cloud computing services are particularly used in higher education across the developed world and in Saudi Arabia to make learning, teaching and research easier without the need to acquire and maintain hardware and software, such as Office 365 and Microsoft Augr.

Other advantages of the cloud presented by [14] are cost-effectiveness, flexibility, easy availability and data safety. Cloud computing can be used to run applications, systems, and IT infrastructure and reduces the need for staff and financial resources. Flexibility means that a user can start on a insignificant scale by buying one node before adding additional resources later. Cloud computing also offers increased data safety in the case of natural disasters or other factors. This approach is very problematic to achieve in a traditional off-site backup. High availability refers to cloud computing providers having improved resources to provide additional time than any other organization.

There are a number of advantages to accepting the use of cloud computing in Saudi Arabia, such as accessing the latest technology with little investment. At the same time, there is no need to build a huge data center and management problems are reduced, removing the burden of acquiring software for each institution from the government's "shoulders". Cloud computing enables access to advanced technology and infrastructure without the need for high expenditure. Cloud computing is one of the new developments in computer technology expected to influence teaching and learning in Saudi Arabia. The architecture proposed in this study is presented in the next section.

4.Proposed architecture

This research proposes An Architecture of a Cloud-Based Virtual Learning Environment as presented in Figure1. This proposal uses the advantages of cloud computing and addresses the limitations of the current VLE system. The proposed architecture is able to easily transfer knowledge and materials between different universities. It consists of the customer, an Internet provider, an Integration component, Third party component, Cloud education and Replication.

1.1. *Customer*

A customer in this section refers to one of the 34 potential user universities distributed throughout the Kingdom of Saudi Arabia. Each user will be able to access the education cloud system via a browser. A username and password will allow them to make a request to access the VLE contents, including new courses made available in the system by other universities.

1.2. *Internet Providers*

STC, Mobily and Zain are the three main Internet providers in Saudi Arabia. These companies provide comprehensive innovative services and solutions, earning customer trust and enriching society. In addition, they offer integrated services for three main sectors: individuals, business, and carriers.

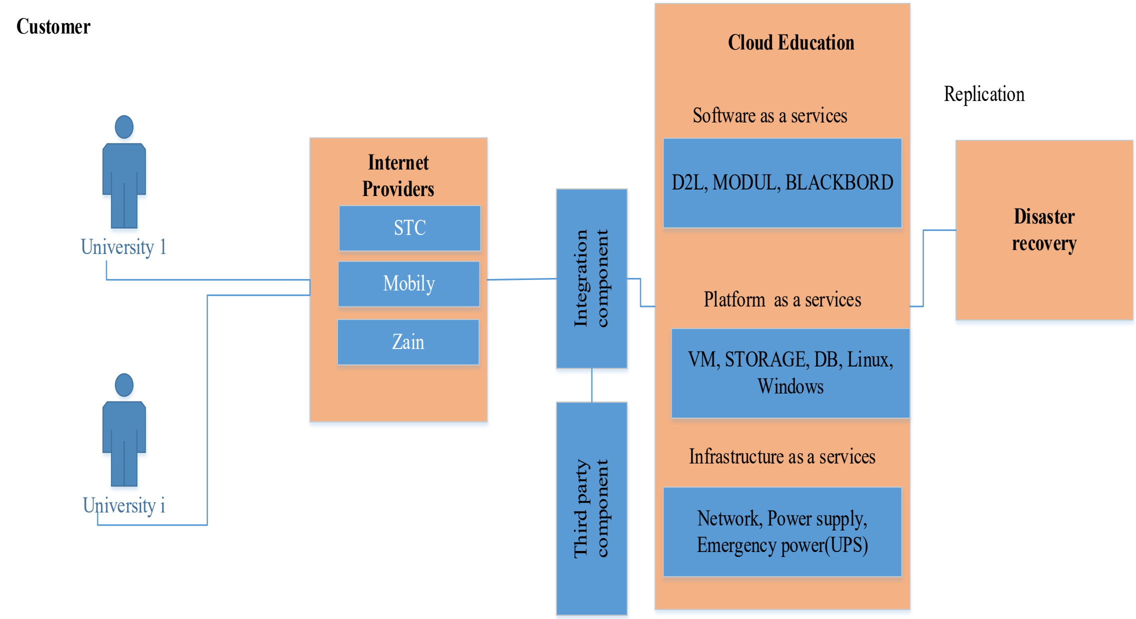

Fig. 1. Architecture of a Cloud-Based Virtual Learning Environment

Fig. 1. Architecture of a Cloud-Based Virtual Learning Environment

1.1. *Cloud education*

Cloud education is a unique entrance point to deal with all the requests coming from different university users to the VLE system. In this paper, Cloud education is defined as a storage system for VLEs. Due to the fact that Riyadh, the capital of Saudi Arabia which is located in the center of the country, it is suggested that cloud education should be built there. Cloud education consists of three layers: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

- Software as a Service (SaaS)

Software as a Service deals with the applications used in VLEs. A user can access this layer via a web browser. Therefore, SaaS uses the web to deliver applications, which are controlled by Internet provider (STC, Mobily or Zain). Therefore, it is not necessary to install VLE applications on the user's PC. SaaS is one of the three layers of cloud education which is observable for customers (end-users), since actual software applications are retrieved and used. The many applications used in VLEs include Moodle, Blackboard Sakai and D2L.

- Platform as a service (PaaS)

This layer is responsible for offering an operation system and support centre to run the software as a service layer. This layer offers developers the opportunity to run and manage applications without the need for the university user to be aware of the maintenance associated with the infrastructure. To build and run on-premises applications is always complex because technical staff are required to manage and control the applications. By using PaaS, the university does not need to employ technical staff to manage and control the applications.

- Infrastructure as a service (IAAS)

This physical layer is the foundation of cloud education. IaaS is an alternative to building a personal data center and purchasing new devices. It contains hardware devices, such as network devices and a power supply. As a replacement for marketing fresh hardware infrastructure, IaaS providers normally offer virtualized infrastructure as a service. IAAS is held and managed by the Cloud education. This layer is flexible as it can offer highly scalable resources that can be modified depending on requests from users, who only pay the producer for what they consume.

1.2. *Disaster recovery system (DRS)*

Disaster recovery system(DRS) is mainly aimed at the business continuity and acts as a form of security to protect data from risks, natural disasters, cyber-attacks and device failures. DRS works only if the main DR fails. The user will not be able to sense any delay while DR is in operation; it provides replication for all activities that happen in the main data center. DRS can replicate servers and any critical devices at other locations to guarantee the continuity of the business. it is suggested that Disaster recovery system should be built in Jeddah which is noted as the second largest city after the capital.

1.3. *Third party component*

Teaching content prepared by individual universities must be protected by a third party. In this research, it is suggested that a Third Party Component should be responsible for any issues related to intellectual property infringement, such as copyright violation or the mishandling of confidential data. This component utilizes some authentication and encryption mechanisms to ensure access control and confidentiality respectively.

1.4. *Integration component*

The integration component is a very important part of this architecture as it works as middleware, which acts as an intermediate layer between applications. This component consists of a list of policies and conditions that allow communication between different applications. It includes some conditions for those who have permission to access the education cloud. There are different layers of user permission, such as read, write, and download.

Some universities are already known as top universities, for example King Saud University. On the other hand, some universities were only established a few years ago. The use of the integration component will ease communication and integration between newer and older universities. Therefore, this component helps new institutions profit from the experience of older ones. This includes access to the questions bank; sharing of course contents; attendance; and the preparation and delivery of presentations.

Different universities will not need to repeat work done by other universities. In other words, there will be no need to reinvent the wheel. This should help universities share knowledge and tools such as virtual labs, videos, tutorials, discussion rooms and presentations.

5. Conclusion

The trending technology of cloud computing has raised a range of new issues. In recent years, the use of VLEs in higher education in Saudi Arabia has increased because they offer many advantages over traditional learning by giving students access to e-resources anywhere and at any time. Cloud computing frameworks are able to provide an environment that has the ability to share knowledge and support different platforms. This paper first introduced the concept of Virtual Learning Environments and discussed the current status of VLEs at Saudi universities. The literature regarding ideas for cloud computing was then reviewed before proposing an architecture of VLE based on the cloud that supports different eLearning platforms. The proposed system is based on cloud computing because of the multiple advantages it offers to institutions, instructors and students alike. This research aims to show that how cloud computing can be used to support the education sector. In the near future, cloud computing will have a considerable impact on education and solve many issues arising in the sector. There are many resources in Saudi universities that could be shared. Cloud computing is growing rapidly in many areas and it is expected that it should soon have a significant impact on VLE systems.

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