Study the size and type of condensation nuclei of rain drop over Baghdad city in (2018)

Hazim H Hussain AL-Saleem¹, Hasan m Azeez² and Nagham T Ibraheem³

¹,²,³Mustansiriyah University, Collage of science, Atmospheric science Department

Email : dr.hazim@uomustansiriyah.edu.iq

Abstract. The current study has been carried out to know the size and type of Condensation nuclei that are responsible for the clouds droplets and that being considered one of the main factors to grow such droplets through using samples of rain drops for Feb and April months. To examine these samples, it has been used two types of devices which are (eds and esm) of high accuracy to know dimensions and components of these nuclei. The current study has indicated that there is a set of the chemical elements of high effectiveness on quantity of saturated water vaporization and represented in the following elements (Na, Cl, Si, Mg, C) depended on its Molecular weight. Max molecular weight has been recorded in the 1st sample and that was for Na, which is 5.63mg and the minimum weight that has been recorded was 0.82 mg, also chlorine CI recorded Max molecular weight 8.46mg and Min molecular weight was 0.3mg. These two elements compose salt and this kind of salt plays a huge role in composing droplets since it is considered soft and there are elements recorded max ratios of molecular weight including silicate Si (28.04)mg and is of a huge effect upon saturated vapour pressure and also there are other elements that could be of effectiveness upon vapour pressure like Carbone C recorded 50.88mg.

Key words: Condensation nuclei, chemical elements

1. Introduction

Water droplets formation is a result of water vapor condensation in the clouds which needs relative humidity. These droplets do not begin to form unless the relative humidity is several hundred percent. However, it is sometimes observed formation of cloud droplets in the atmosphere if the rising air reaches the balanced saturation ratio because the atmosphere contains important concentrations of particles with microns and sub-microns in radius called (condensation nuclei) they have a water tendency and are used as condensation nuclei, the condensation of water vapor on condensation nuclei is called (heterogeneous nucleation) and depends on particle size and chemical composition [1].

Condensation nuclei or so-called aerosols are classified as being hydroscopic, neutral and hygroscopic [2].

It was found that the hydroscopic aerosols need a much higher saturation ratio than calculated from Kelvin's equation, and hygroscopic aerosols need much less saturation ratio than calculated from Kelvin's equation, where this equation explains the relationship between water droplet size and vapor
pressure when the mass of the droplet decreases, the vapor pressure needed for equilibrium will increase \[1\].

Natural aerosols have radius between \((10^{-3} \text{ m})\) to \((10^{-1} \text{ m})\). These include salt, dust, and hydrocarbons. Continental aerosols (with a diameter greater than \(0.1 \text{ m}\)) has three main compounds: salt which its radius is \((1 \text{ m})\), sulfur compounds with radius between \((0.1 \text{ m})\) and \((1 \text{ m})\), and insoluble particles resulting mostly from soil \[3\].

The condensation nuclei, which are part of the atmosphere, are classified as Junge distribution, which is based on size and is as follows: Large particles with radius much more than \(10^{-1} \text{ m}\), coarse particles whose radius is less than \(10^{-1} \text{ m}\) known as PM10, the particles are soft and have a radius less than \(2.5 \text{ m}\) (PM2.5), Aitken Nuclei particles that have a radius less than \(1 \text{ m}\), these particles are also known as condensation nuclei, some of them are known as giant Aitken nuclei which have radius more than \(1 \text{ m}\), and some of these have radius between \(0.2 - 1 \text{ m}\) and are known as the large Aitken nuclei \[4\].

 Köhler curve explains the saturation ratio as a function of droplet size as shown in figure below:

\[\text{Relative humidity (\%)}\]

\[\text{Super-saturation (\%)}\]

\[\text{Droplet radius (\text{\mu m})}\]

\[\text{Figure (1) Köhler curve}\]

This shape explains the variations of the relative humidity and super saturation ratio to a droplets of pure water (curve 1) against solution droplets containing the following mass of salt: (2) \(10^{-19}\) kg of NaCl, (3) \(10^{-18}\) kg of NaCl, (4) \(10^{-17}\) kg of NaCl, (5) \(10^{-19}\) kg of \((\text{NH}_4)_2\text{SO}_4\), (6) \(10^{-18}\) kg of \((\text{NH}_4)_2\text{SO}_4\) \[5\].

The nuclei involved in the formation of clouds are only those that are active in the amount of super saturation of \(1\%\) or less and expressed as cloud condensation nuclei (CCN) to distinguish them from the condensation nuclei in general \[6\].

Köhler's calculations assume that nuclei with initial radius \((1 - 2 \text{ m})\) need to grow to about \(50 - 100 \text{ m}\) to form cloud condensation nuclei in the boundary layer clouds \[7\].

The figure below shows a change in particle sizes due to condensation, evaporation process and final size of active cloud droplets \[3\].
2. Results and discussion

It is necessary to form the droplets of the cloud that there are condensation nuclei that are at the beginning of the droplet and remain these nuclei in the droplets until they grow and turn into droplets falling to the ground; these nuclei vary in terms of shapes and sizes and originates of their presence, thus the densities of rain droplets were studied, which play a large role in the formation of clouds. To know the type and size of these nuclei, samples were taken of rain falling over the city of Baghdad for two different periods, Where the first was in February 17/2/2018 and the other in April on 10/4/2018, and after the collection of samples by laboratory slides were analyzed in the service laboratories of the College of Science University of Baghdad by the device (EDS and SEM) and shown in the figure below:

![Figure (3) SEM](image1)

![Figure (4) EDS](image2)

The results indicate that there are different densities in their sizes and shapes according to the measurements of the (SEM) device which is used to measure, examine and enlarge the biological, chemical and physical samples based on the energy of the electrons emitted from the source. The
device sends a bundle of electrons through the source of the electrons of the device as it passes through a set of magnets that condense and assemble this package to fall on the surface of the sample and emit electrons from the surface of the sample where it receives two types of recipients (backscattered electron receptor, secondary electron receptor) The X-ray detector receives the electrons emitted from the surface of the sample and analyzes them into the elements that are formed, as shown in the following illustration.

Figure (5) The operation mechanism of the device

The samples were analyzed and the sizes of these nuclei (which measured in micrometer units) were different from one sample to another, some of them are caused by pollen, including dust storms, some of the salts produced by sea waves, and even by the combustion of engines. It can be said that it can act as a condensation nuclei, the effectiveness of these nuclei depends on their ability to assimilate in the atmosphere with the presence of relative humidity as shown in figures below.
Figure (6) The condensation nuclei of the first sample of rain in 17/2/2018 at 9:25 am
After examining the samples, it was found that they contain chemical elements represented by the nuclei in which the images above are diameters of varying degrees as well as different molecular weights. Here the molecular weight is very important. Where the greater the molecular weight, the effectiveness of these nuclei and their ability to form droplets will be larger as well as being of different sizes in the case of super saturation as in the table below:

**Table (1) elements of the first sample**

| C  | Na  | Mg  | Al  | Si  | Cl  | Ca  | Ni  | Zn  | Ag  | Pt  | S   | K   | Fe  | Cr  |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 5.7| 5.63| 1.51| 0.62| 23.49| 5.37| 4.83| 0.96| 0.41| 13.17| 3.69| 0.42| 0.68| 2.39| 1.26|
| 6.27| 1.91| 0.82| 0.48| 7.2 | 8.46| 1.01| 6.91| 0.96| 27.7 | 7.88| 0.02| 0.57| 1.3 |
| 9.18| 3.7 | 3.34| 2.24| 22.53| 0.37| 9.57|     |     |     |     |     |     |     |     |
| 8.47| 4.96| 2.92| 1.64| 28.04| 0.3 | 7.55|     |     |     |     |     | 0.42| 1.1 |
| 50.88| 0.82| 0.75| 0.38| 24.55| 1.19| 13.12|     |     |     |     |     |     |     | 0.42|
| 31.35| 3.27| 1.09| 0.45| 20.48| 8.55|     |     |     |     |     |     |     |     |     |

**Table (2) elements of the second sample**

| C  | Na  | Mg  | Al  | Si  | Cl  | Ca  | Ti  | Cu  | Fe  | K   | Au  | Sr  | L   | P   |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 32.95| 0.2 | 2.2 | 3.43| 10.13| 0.14| 1.68| 0.25| 0.07| 6.95| 0.83| 2.52| 2.31| 10.11|
| 18.14| 1.75| 3.69| 3.85| 17.28| 0.22| 5.91| 0.33| 0.05| 2.06| 0.4 |
| 23.79| 5.42| 11.76| 0.57| 4.02| 20.98| 13.48| 0.24| 0.42|     |     |     |     |     |
| 37.56| 7.6 | 1.39| 0.51| 25  | 0.72| 5.27| 0.29| 1.22|     |     |     |     |     |
|     |     |     |     |     |     |     |     |     |     | 0.23|     |     |     |
| 4.34| 0.98| 0.44| 16.04| 24.21| 0.23|     |     |     |     |     |     |     |     |
| 3.56| 0.91| 0.43| 23.56| 8.41 | 0.51|     |     |     |     |     |     |     |     |

The results showed in the table above a number of chemical elements in the droplets, which have different molecular weights according to their areas of existence and their emergence is moving from one place to another and this means that its concentration or presence does not mean that it was formed in the place where the sample was taken from it is spread in the atmosphere, Some of which becomes the nucleus of condensation and the other remains in the atmosphere and be ineffective, therefore it is known that the greater the amount of solution makes the process of growth of the droplet faster, as the solution which is the nucleus of the satiety does not prevent the saturated vapor pressure from stopping the growth and increase radius of the droplet and the solute effect (Raoult's law).
\[
\frac{e'}{e_s} = 1 - \frac{b}{r^3}
\]

where:

\[
b = \frac{3im_s}{4\pi\rho_l M_s} M_w
\]

\(i\) : ion factor

\(m_s\) : mass of solute

\(\rho_l\) : density of water

\(M_w\) : molecular weight of water

\(M_s\) : molecular weight of solute

The condensation nuclei are usually hygroscopic and are usually salts. These salts are in the form of compounds. In Table 1, the elements of the first sample show the presence of sodium and chlorine together, which, if combined, is a composite of sodium chloride (NaCl). It is originally salt and since the salts are melted in the presence of water vapor represented by the relative humidity so it will be the source of the condensation nuclei. Note that sodium chloride is one of the best types of condensate nuclei, as proved by laboratory and according to the equations above. Table 1 showed the presence of molecular proportions of these elements. It was observed that the ratio of sodium in sample (1) was the highest of the molecular weight (5.63) mg and the lowest percentage of molecular weight (0.82) mg as well as chlorine was the highest weight Molecular is (8.46) mg and the lowest is (0.3) mg.

Although there are good elements that can act as nucleic acids such as silicate (Si), calcium (Ca), magnesium (Mg) and others. But may have a small impact on the proportion of saturated vapor, such as silicate, which has the highest value of its molecular weight (28.04) mg as well as the rest of the elements may be of large molecular weights but the effect is weak as most of them are already present in the atmosphere or formed in another drop. Carbon, which has the highest molecular weight is (50.88), and when the process of adhesion with other droplets, the two exist together as it is not necessary to have the two elements together to be composite because these elements can act as a condensed but weak.

As for the second sample in Table (2) we also note the presence of the same elements with the presence of the element of sodium and chlorine in good proportions where the highest molecular weight of the element of Na (Na) is (5.42) mg and the lowest molecular weight is (0.2) Also for chlorine, the sample contained the highest molecular weight (20.98) mg and the lowest molecular weight (0.14) mg.

In the first and second tables, we observed the presence of the silver element in molecular weight (13.17 and 27.7) respectively. Silver iodide is known to be effective when used in industrial perfusion, but the absence of iodine makes the effect of silver is weak.
3. Conclusions

1. The nuclei of the condensate are pure salts in the form of elements or compounds that are affected by saturated vapor pressure according their molecular weights.
2. There are influential and ineffective elements that can be intended to intensify or come from the atmosphere or another drop of rain in the process of Coalescence.
3. The condensation nuclei of the droplets depend mainly on their area of origin or the area from which they originated.
4. The size of the nuclei of the condensation varies according to the nature of the element and their forms are irregular.
5. The presence of such elements as carbon, silicon, calcium, magnesium, zinc, etc., which worked as nuclei as it appears to be apparent from their molecular weights.

4. References

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