The evolving chemical composition of C/2012 S1 ISON as it approached the Sun

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Shortly after its discovery by Vitali Nevski and Artyom Novichonok on September 21, 2012, the orbit of C/2012 S1 ISON was determined, indicating a perihelion passage very close to the Sun (0.012 au) in late November 2013. Initial observations suggested that ISON could be quite bright with a long period of favorable observing conditions leading up to perihelion, followed by a close post-perihelion approach to the Earth (0.42 au) in December 2013. Comet ISON thus became the first sungrazing comet discovered early enough to be studied for many months prior to perihelion, through its close solar passage, and potentially after perihelion. This spurred a worldwide campaign to coordinate observations of ISON from numerous facilities covering a broad spectral range. We report volatile abundances in comet ISON as determined from high-resolution (R $\sim$ 25,000) infrared spectroscopy. Our strategy was to use the NIRSPEC spectrometer at the 10-m Keck observatory and the CSHELL spectrometer on the 3-m IRTF telescope. We proposed to use NIRSPEC when the comet was fainter but still available during darktime (October through early November 2013 pre-perihelion, and January 2014 post-perihelion), and CSHELL when the comet was brighter and closer to the Sun, but only available during daytime. Although observations on many dates were lost owing to poor weather, and the disruption of the comet near perihelion prevented any post-perihelion observations, successful observations were obtained with NIRSPEC on October 26 (R_h= 1.12 au, Δ = 1.38 au) and October 28 (R_h = 1.08 au, Δ = 1.32 au), and CSHELL on November 19 (R_h = 0.46 au, Δ = 0.86 au) and November 20 (R_h = 0.43 au, Δ = 0.86 au). All dates are specified in UT.

The primary results from these observations are as follows. (1) The overall volatile productivity as measured by the H_2O production rate increased from $\sim 10^{28}$ molec/s on October 26 and 28 to ~ 3–4×10^{29} molec/s on November 19/20. (2) The volatile production rate was increasing rapidly as ISON approached perihelion, and we investigate whether statistically significant variations in volatile production rates are seen on November 19 between UT 17:15 to 23:00. (3) The relative abundances of some measured volatiles with respect to water remained constant during this time period (e.g., C_2H_6 and CH_3OH), whereas others increased significantly from late October to November 19/20 (e.g., C_2H_2, NH_2, NH_3). (4) Comparison of the measured spatial distributions within the coma of ISON on November 19 show differences that suggest some species are released from extended sources in the coma as well as ices in the nucleus. (5) C_2H_6, CH_3OH and CH_4 appear slightly depleted relative to H_2O in ISON compared to other comets. C_2H_2, HCN, and OCS abundances appear to be in the typical range on November 19, although C_2H_2 abundances appeared depleted in October. Abundances of H_2CO, NH_2, and NH_3 in November were significantly enhanced compared to other comets, with NH_3 abundances being the highest measured to date in any comet. This contrasts with measured abundances and upper limits for NH_2 and NH_3 in late October, which are closer to the typical values seen in comets.

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